PRODUCT ENGINEERING

VOLUME 7 NUMBER 6

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July Number

This month we describe a simple oxidation test for bearing greases. Serviceability is another test that greases must pass. For this purpose the Bearing Engineers Committee, made up of engineers of six of the leading anti-friction bearings manufacturers, developed a machine for testing the serviceability of greases. It is known as the B.E.C. testing machine. How it is used and the significance of the test results, will be the subject of an article in the July number. As is the oxidation testing machine described in this issue, the B.E.C. machine is simple to operate and the results of the test are easy to evaluate.

Resilient rubber mountings vary according to not only the shape and design of the mounting but also according to the rubber used. Hence test results are the only certain method for determining if the mountings will be satisfactory. July *P.E.* will describe a simple machine for doing this.

Other July articles include the continuation of the series on how to make alignment charts, drafting room methods and management, and the second part of the article on X-ray analysis. In addition, there will be the usual departments.

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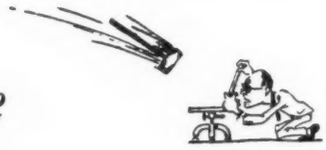


A Little Premature

PRODUCT ENGINEERING
NEW YORK

The first of the new series of articles on drafting room methods and management by J. K. Olsen was interesting reading. But I am wondering if this series is going to duplicate the Drafting Standards of the American Standards Association. Why publish things in *Product Engineering* that are already published elsewhere, and in this instance, I dare say better? —W.J.B., *Chief Draftsman*
Newark, N. J.

WE assure W.J.B. that J. K. Olsen is not in competition with the A.S.A. and that *Product Engineering* is not rehashing articles that are published to better advantage elsewhere. The Olsen articles will deal with the activities and management of the drafting room, rather than the drawing standards.

An Error of Omission

PRODUCT ENGINEERING
NEW YORK

In the February number of *Product Engineering* under the heading of Manufacturers Publications on page 77 at the bottom of the center column you have listed "Precision Needle Roller Bearings." The manufacturer's name, however, is not given. We would appreciate your supplying us with this information as we are especially interested in these bearings. —H.R.B.
Paterson, N. J.

WE must confess to the error in having omitted the name of the company. The publication "Precision Needle Roller Bearings" is issued by the Norma-Hoffmann Bearings Co. of Stamford, Conn. Our apologies to them.

Nitrided Gears

PRODUCT ENGINEERING
NEW YORK

We would like to obtain up-to-date information regarding the nitriding process as applied to small gears. We have in mind gears ranging from 2 in. to 8 in. pitch diameter. What are the specific steels that respond more favorably to the nitriding process? What are the operating details of the process or procedure and what equipment would be necessary to install a small sized nitriding department? How do nitrided gears compare with care hardened or through hardened steel gears?
—J.I.S., *Vice President*
York, Pa.

OF course the answers to most of the above questions are readily obtainable from the Nitralloy Corp. of 230 Park Ave., New York City; but we would like to get some first-hand information as to the experiences in the use of nitrided steel gears versus case hardened and through hardened gears. Also are such gears receiving greater attention at this time?

He's A Professional

PRODUCT ENGINEERING
NEW YORK

Referring to the description of the new Erie meter system pump which appeared in the April number of *Product Engineering*, can you tell us whether Mr. Wilbur Henry Adams is a professional commercial artist, and if so, what is his address. —C.W.D.
Newark, N. J.

MR. Wilbur Henry Adams is what is variously called a professional commercial artist or industrial designer. His offices are at 2341 Carnegie Ave., Cleveland, Ohio. The new Erie meter system gas pump is only one of the many jobs he has done.

Strength of Split Tube

PRODUCT ENGINEERING
NEW YORK

A discussion arose with reference to effective shafting. Everyone agreed that with the same amount of material a shaft stronger in torsion can be made by using a seamless tube. Then someone brought up the question of comparative torsional strength of a seamless tube with the same tube split on one side. But we were unable to find any formula in our handbook making the slightest distinction between the solid seamless tube and the "cracked" tube or split tube. We decided the quickest and possibly the safest way would be to write you for further information. —H.E.G., *Research Engineer*
Chicago, Ill.

WE do not claim to be any Oracle of Delphi. And we cannot point to an article in *Product Engineering* giving the solution to this particular problem. But if those interested will refer to Applied Elasticity, first edition by Timoshenko and Lessells, published by the Westinghouse Technical Night School Press, E. Pittsburgh, Pa.; or the book Strength of Materials by Timoshenko published by D. Van Nostrand, 250 Fourth Ave., New York City, they will find the solution to this problem.

Trouble for Clippers

PRODUCT ENGINEERING
NEW YORK

I would like to have an extra copy of "Flexible Couplings III and IV." Since I clip some of the articles, I really do not appreciate the articles having charts which go to the edge of the page. —M.D.H.
Hartford, Conn.

A GLANCE through this issue will show quite a number of instances wherein we have committed the unappreciated. But, by trimming the pages to leave only a half-inch margin on the one side, the full margin can be retained along the other edge to make a width of 8½ in. Similarly by trimming off the top of the page when the line drawing goes to the bottom of the page, or vice versa, the page height can be reduced to 11½ in. with no interference to drawings.

Design of Power Presses

PRODUCT ENGINEERING
NEW YORK

In the several years which I have taken *Product Engineering*, I have not received an issue bearing an article closely or barely remotely related to the work which I am interested in, namely, the design and operation of power presses in particular, and sheet metal working machinery in general. This opinion is borne out by my fellow engineers.
—W.B.S.
Toledo, Ohio

WE have had no articles in *Product Engineering* on the design of power presses as such. But, numerous articles have appeared on stress calculations, lubrication problems, bearing designs, material selection and similar factors that are applicable to power presses as well as other types of machinery. On the other hand, perhaps W.B.S. has in mind some specific problems relating to power presses, and perhaps other readers have some thoughts along this line also.

Forgings versus Castings

PRODUCT ENGINEERING
NEW YORK

Referring to your comments in respect to the letter "Forgings versus Castings" from R.E.W., of Gettysburg, Pa., please put us on record as being highly interested in the proposed article on the design possibilities through the use of precision forgings. The writer believes that a comparison with castings for certain applications would be very constructive. —C.W.D.
Orange, N. J.

THIS reader is voicing the sentiments of numerous others. We have already put our plans into action and in the near future will present a comprehensive article in *Product Engineering* on the subject of the design possibilities in the use of forgings.

PRODUCT ENGINEERING

GEORGE F. NORDENHOLT, *Editor*

MCGRAW-HILL PUBLISHING CO., INC. JUNE 1936 VOLUME SEVEN, NUMBER SIX

Control

AS EACH year passes product engineers write into the history of our times new applications of physical laws through the medium of the mechanisms they design. To the layman—the consumer who reaps the benefits of these developments in added convenience or greater leisure—the achievements of the engineer are taken very much for granted. Witness the first commercial round trip of the dirigible Hindenburg from Germany to Lakehurst with passengers, mail and express. The event was front page news yet few people got very much excited about the matter.

But to the engineering profession current developments are highly significant, largely because of the constantly growing magnitude of the forces and stresses involved in some of them, and the consequent need for better and better methods of control. With this thought in mind we have devoted most of the editorial pages in this number of *Product Engineering* to consideration of the latest types of electric and hydraulic control apparatus and applications.

Competition between the advocates of these two types of control and operating devices is keen, which is probably a good thing because of the stimulating nature of such rivalry. It will be obvious to engineers that some applications demand electric control or operating equipment, or both, while others are quite as definitely appropriate for hydraulic apparatus. In between these extremes lies an extensive field of applications where the engineer can exercise a choice as to which he will use. It is to help in the making of such decisions that we have included articles on both electric and hydraulic mechanisms in this number.

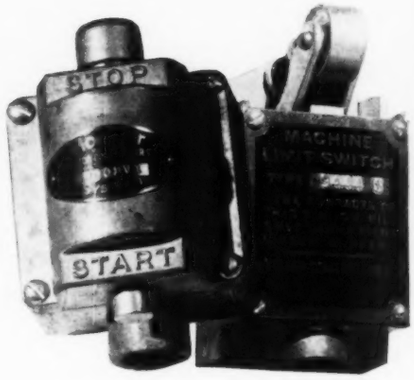
Besides the almost infinite variety of devices exclusively in one or the other of the two fields, the engineer must reckon with the many possibilities of combining the two to advantage, as has been so well demonstrated by the machine tool designers. Among the typical circuits and mechanisms described are several that fall in this category.

In both fields, fortunately, the art has developed to the point where standard units are available at reasonable cost. Thus the product engineer can accomplish his object without having to contend with the expense of mechanisms that must be specially designed and built.

ANOTHER very real advantage of this situation is that the manufacturers of the various standard units have accumulated quantities of engineering information based on research, tests and the experience of their engineers in consulting on applications of their respective products. No product engineer worthy of the title will hesitate to take full advantage of such information as this which is to be had for the asking. If he has any compunctions about requesting help from the engineers of a parts manufacturer, let him remember that the additional experience which will accrue to the parts builder and his engineers, through work on one more application, may well be valuable to them. Thus the help he obtains from them is often of mutual benefit.

Applications of Electrical Devices for Automatic Operations

Examples of machines that are automatically controlled by timers, solenoids, solenoid valves, magnetic brakes, rheostats, relays, motor controls and similar units, with wiring diagrams to show how cyclic control, and other automatic features are obtained

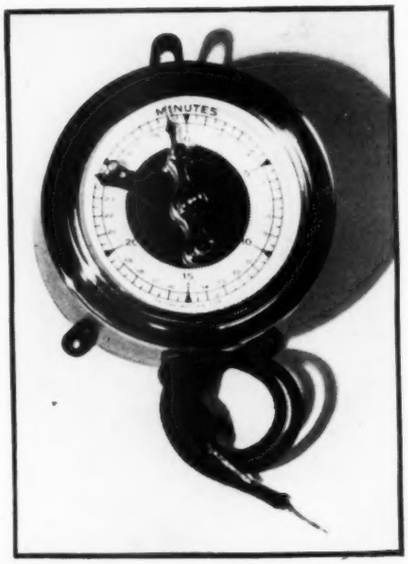


IN THE examples of applications of electrical devices for controlling machines, as described here, some results obtained through the use of automatic timers, magnetic brakes, solenoid actions, limit switches, relays and rheostats are pointed out. Innumerable combinations are possible.

Because most of the electrical items are not special but can be obtained from standard stock, costs are relatively low. For the same reason, the mechanical designer does not need to know the fine points of electrical design. Correct use and application of the devices can be assured by consultation with the engineers of the manufacturers.

Similar results can be attained by using different combination of elements and much latitude exists in the choice of the mechanisms used and their arrangement. The final choice is usually determined by specific service conditions and requirements to be met.

Variable-speed transmissions, now obtainable with mechanical or electrical control, are used for maintaining constant surface speed on winding and cutting operations, for adjusting tension in wire drawing and textile finishing machines, and for varying speeds in some types of processing machinery. The speed controlling unit may be a pressure or temperature regulator, governor, float, photo-electric cell or other indicating device.

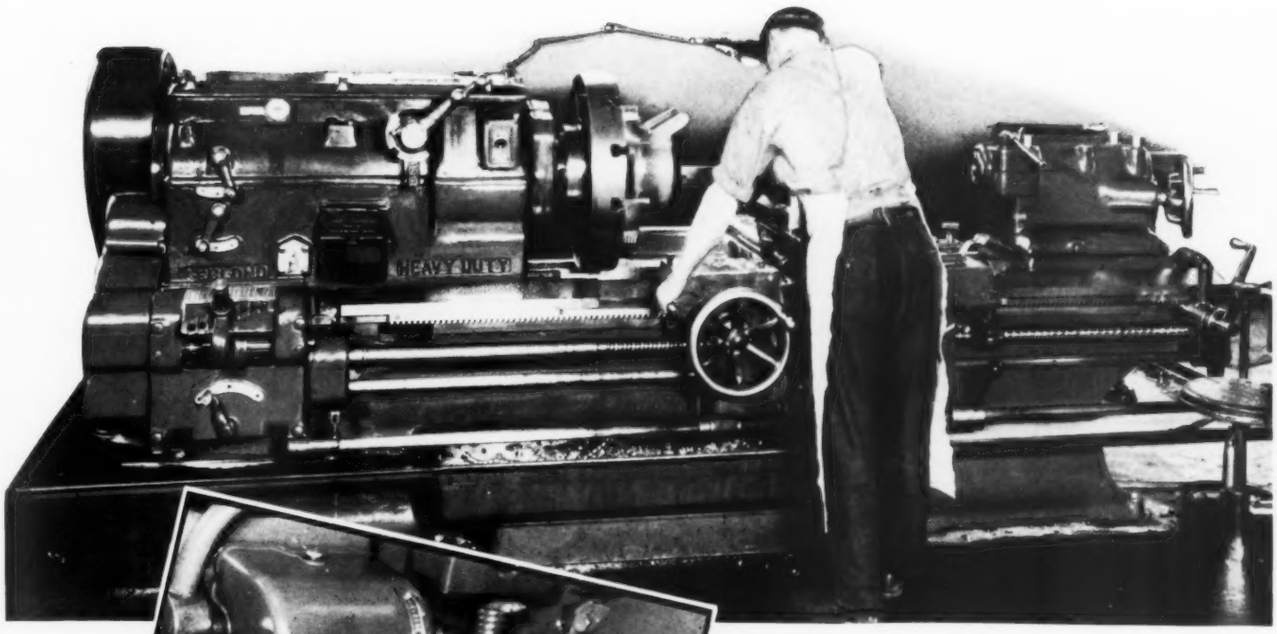


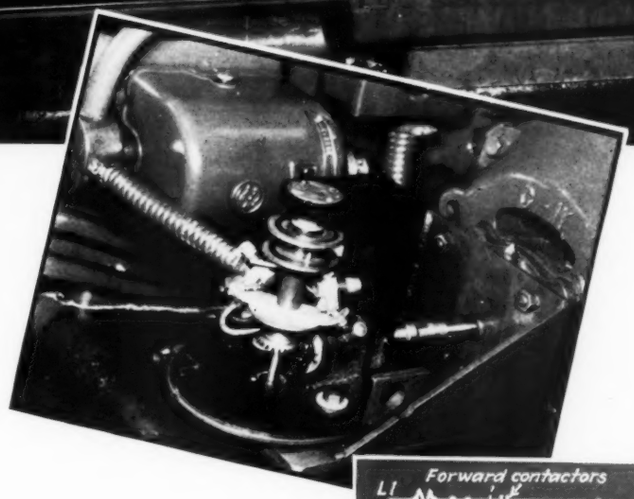
In many automatic machines, mechanical means are still being used for automatic stopping in case of jamming or a part failing to feed. Many of these stops are highly ingenious and serve their purpose as long as speed and inertia forces are relatively low. But speeds are being increased and machines are being made heavier. This has led to the necessity of devising automatic stops that will operate faster and more positively. Magnetic clutches and brakes is one solution and numerous new applications of these devices have been developed in recent years.

In several designs of automatic assembling machines a magnetic clutch and brake combination is used. Should any of the pieces being assembled fail to position properly an electrical contact is made in a relay circuit. This immediately disengages the clutch and simultaneously applies the brake, stopping the machine within a fraction of a revolution. Similar arrangements are being worked out for automatic packaging machines, in some instances photo-electric cells being used to control the brakes and clutches.

Magnetic clutches are also used to serve as slip couplings, as in tapping and nut-driving machines. Another reason for their use is the simplicity for remote control.

Not only light machines, but al





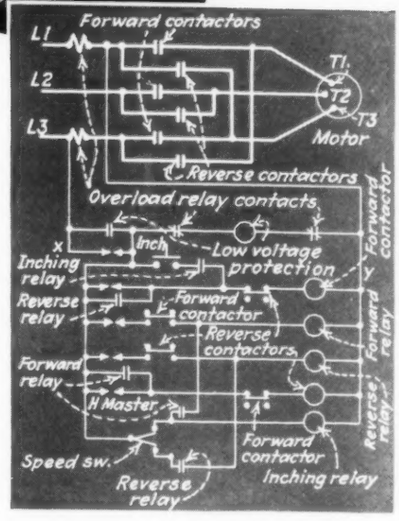
Centrifugal Speed Switch for Inching

the heaviest types of machines are using magnetic clutches. One manufacturer of grinders is about to announce a new model using a magnetic clutch in the drive. The latest rolling mills are equipped with magnetic clutches for the screw-downs.

Motors with built-in magnetic brakes are being used in numerous applications where quick stopping is desired; where coasting of the machine might cause damage or be dangerous.

The possibilities in the selection of control panel equipment, are made evident in the following descriptions of applications of electrical devices for machine drives and control. Often it is easy to achieve complete sequence of operation by the use of control equipment that does not require external devices.

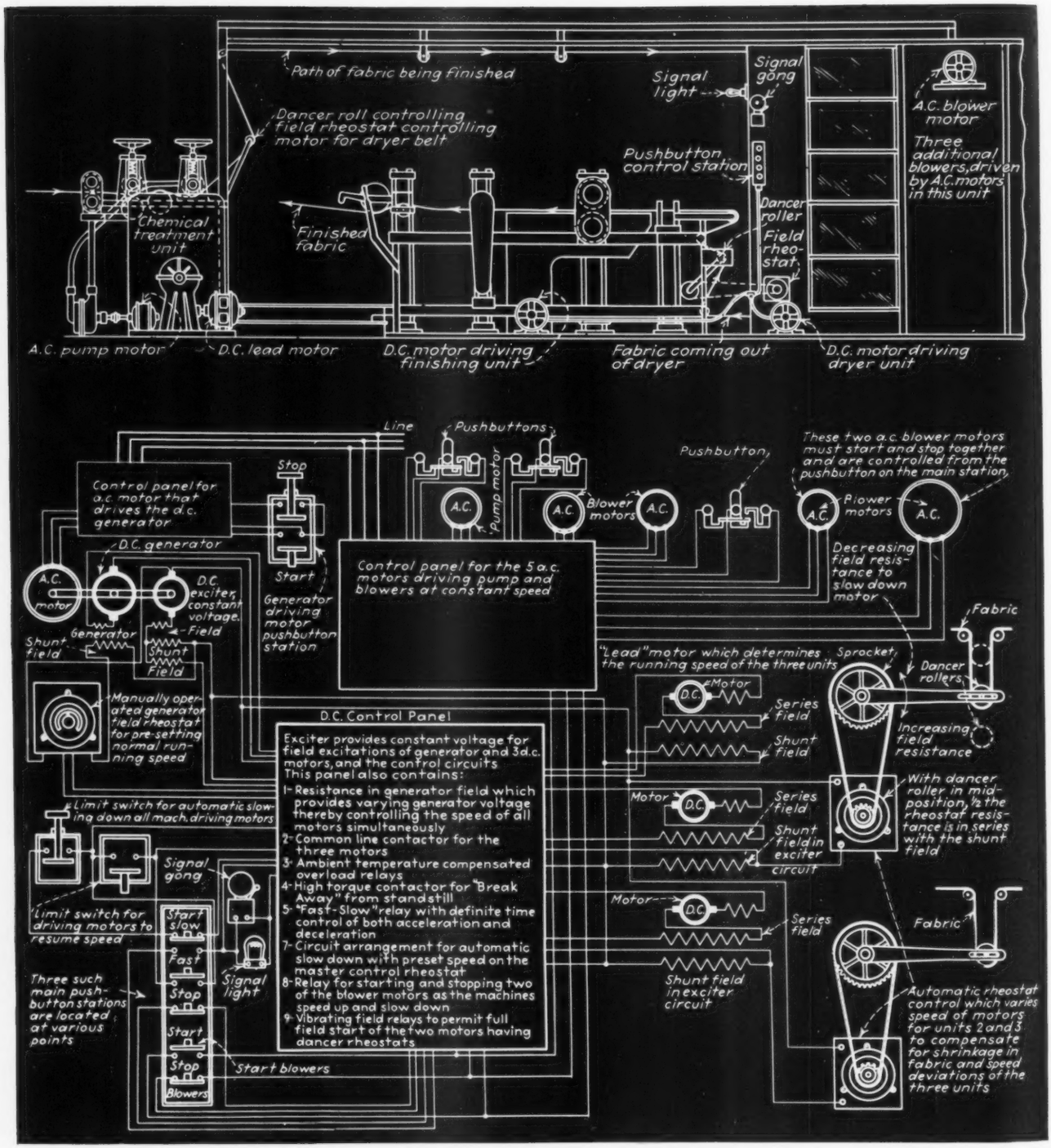
Because there are no hard and fast rules to guide one in the selection and layout of electric drives and controls, and since the developments in this field are extremely rapid, designers should make every effort to learn about the latest possibilities before making a decision in regard to the arrangement of an installation. Not only a thorough search of the literature on the subject is desirable, but also in addition, it is often very advantageous to cooperate closely with the manufacturers of the electrical equipment involved. Indeed, this last is in almost every instance essential if the designer is to make sure that the various electrical devices will operate in proper coordination.



NO MECHANICAL clutch or brake is used in this LeBlond lathe. Starting, stopping, and reversing are done electrically and are controlled by a lever either at the front or back of the carriage.

For inching, a speed switch driven from the motor shaft, as shown, a pushbutton, and a relay are used to furnish a succession of short impulses to the motor. The switch mechanism is a gear driven rotor carrying three slip rings. Electrically connected between the rings are two mercury tube switches held at a small angle off the horizontal. The angle can be adjusted and set to increase or decrease the time interval between starting and stopping. When at rest the tube circuit is open. With the motor turning, the revolving rotor sets up a centrifugal force which throws the fluid meduim in the tubes to the outer end, completing a circuit. The speed switch is so adjusted that when inching it energizes relay *C* almost as soon as it receives motion, which then opens the inching pushbutton circuit. A simplified wiring diagram of the electrical hook-up is shown.

The 24 in. heavy-duty LeBlond lathe shown, is equipped with "Zero-


Path of fabric being finished
Signal light
Signal gong
A.C. blower motor
Three additional blowers, driven by A.C. motors in this unit
Dancer roll controlling field rheostat controlling motor for dryer belt
Pushbutton control station
Dancer roller
Field rheostat
Chemical treatment unit
Finished fabric
A.C. pump motor
D.C. lead motor
D.C. motor driving finishing unit
Fabric coming out of dryer
D.C. motor driving dryer unit
Line
Pushbuttons
Pushbutton
These two a.c. blower motors must start and stop together and are controlled from the pushbutton on the main station
Control panel for a.c. motor that drives the d.c. generator
Stop
Pump motor
Blower motors
Blower motors
D.C. generator
A.C. motor
D.C. exciter, constant voltage
Start
Generator driving motor pushbutton station
Control panel for the 5 a.c. motors driving pump and blowers at constant speed
Decreasing field resistance to slow down motor
Generator
Field
Shunt field
Shunt Field
Fabric
"Lead" motor which determines the running speed of the three units
Sprocket
Dancer rollers
Manually operated generator field rheostat for pre-setting normal running speed
Motor
Series field
Shunt field
Increasing field resistance
D.C. Control Panel
Exciter provides constant voltage for field excitations of generator and 3 d.c. motors, and the control circuits
This panel also contains:
1- Resistance in generator field which provides varying generator voltage thereby controlling the speed of all motors simultaneously
2- Common line contactor for the three motors
3- Ambient temperature compensated overload relays
4- High torque contactor for "Break Away" from standstill
5- "Fast-Slow" relay with definite time control of both acceleration and deceleration
7- Circuit arrangement for automatic slow down with preset speed on the master control rheostat
8- Relay for starting and stopping two of the blower motors as the machines speed up and slow down
9- Vibrating field relays to permit full field start of the two motors having dancer rheostats
With dancer roller in mid-position, ½ the rheostat resistance is in series with the shunt field
Limit switch for automatic slowing down all mach. driving motors
Signal gong
Limit switch for driving motors to resume speed
Start slow
Fast
Stop
Start
Stop
Blowers
Signal light
Three such main push-button stations are located at various points
Start blowers
Shunt field in exciter circuit
Fabric
Automatic rheostat control which varies speed of motors for units 2 and 3 to compensate for shrinkage in fabric and speed deviations of the three units

speed Control." A 15 hp. Crocker-Wheeler motor drives it, an Electric Controller & Manufacturing Company's reversing and plugging starter is used for control, and Dunco relays are used throughout. The coolant-pump is driven by a ¼ horsepower motor. A force-feed lubrication pump is built into the machine. Features of the design are: elimination of maintenance adjustments of mechanical clutch and brake, and accessibility of all manual controls for feeds and traverses with consequent speed and ease of operation.

Range Drive Speed Control

IN THE three-unit textile finishing machine drive designed by the Monitor Controller Company, the Ward-Leonard system controls the relative speed of the three driving motors by changing the shunt field resistance in the d.c. generator. In addition, the speed of two of the d.c. motors can be varied independently by a shunt field rheostat actuated by a dancer roller.

High "break-away" starting torque on the d.c. motors is obtained by a vibrating rheostat in the d.c. circuit. High starting current actuates a relay that cuts out the shunt field resistance. This causes a drop in the armature current, causing relay to again cut in the resistance. Thus the relay "vibrates" till running speed has been reached.

Another feature is that the overload relays are compensated for ambient temperature.

Automatic Cycle Control for Cleaning Machine

IN THE automatic cleaning machine built by the Prosperity Company, seven operations—washing, rinsing, extraction, tumbling, drying, deodorizing and distilling—all take place in proper sequence and run for a scheduled time.

Regulation is accomplished by a cut disk which has for each operation a slot the length of which determines the working time. The disk is placed on a motor-driven turntable called a "Formatrol." Contact fingers pressing down on the record disk complete circuits as the fingers drop through the perforations, thereby controlling all the valves and motors through Dunco relays in a pilot circuit. Solenoid valves open or close steam, water supply and similar lines.

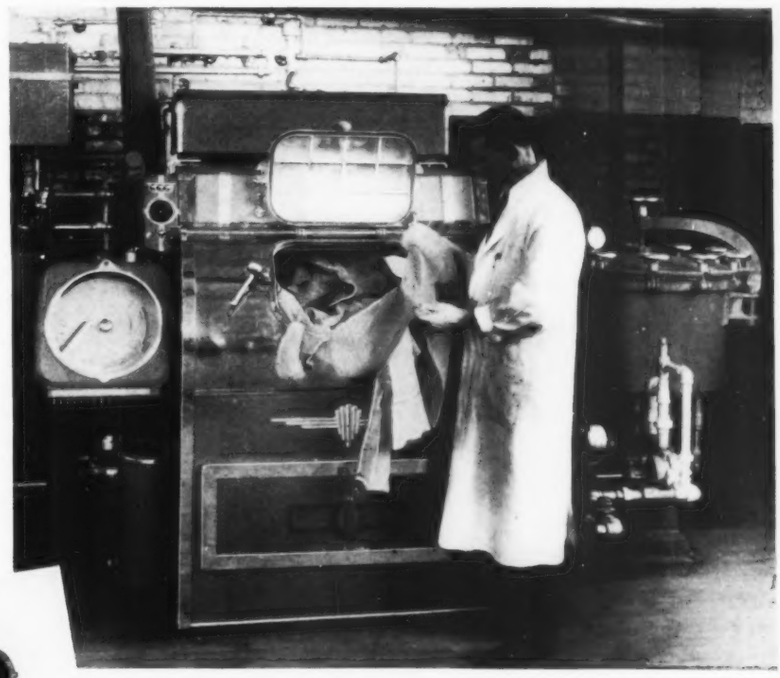
After the garments are distributed in the wash wheel, the doors are closed and secured. With a record in place the switch is turned on. No further attention is required until the cleaning and drying are completed. For special runs the machine can be manually controlled by pushbuttons.

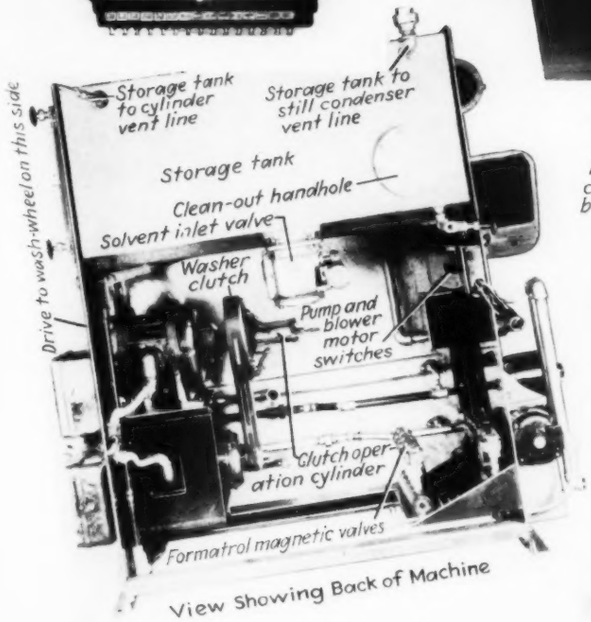
Revolving at slow speed, the rotation of the wheel is reversed four times a minute for a six minute washing period. Then a special valve opens and the dirty solvent flows into a sump tank, from which it is pumped into a still and when distilled, the now chemically pure solvent flows back into the storage tank.

A rinse bath follows the first washing period. A valve admits clean solvent, the wash wheel continues to rotate and reverse, and then stops at the preset time. A dump valve is then opened automatically allowing the liquid to flow into the sump tank.

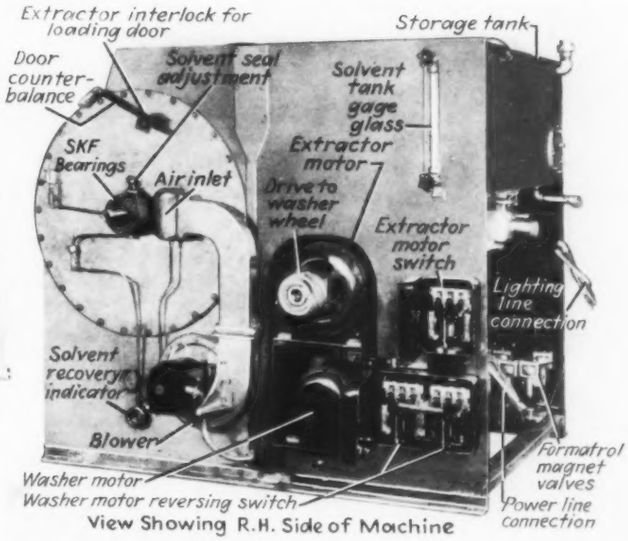
After rinsing comes extraction of the solvent by centrifugal action. The wash wheel is run at high speed for three or four minutes, with the dump valve open, the extracted solvent being pumped to the still. When extraction is finished, the motor stops and the dump valve closes, all automatically.

During washing and rinsing, and for drying and deodorizing which follow extraction, the clothes wheel is driven by a speed-reducer motor, which is reversed by a timer driven by the formatrol motor. Drive is by V-belt on washer motor to air-oper-





View Showing Back of Machine



View Showing R.H. Side of Machine

ated clutch-sheave on large extractor motor, then to V-sheave on other end of armature shaft and then to washer wheel. When washer motor is driving, the extractor motor armature shaft serves merely as a countershaft. When extractor motor drives the wheel, the air-operated clutch on its shaft is disengaged automatically.

In drying, with the temperature automatically controlled, the solvent remaining in the clothing is vaporized by heated air circulated through the revolving wheel by a blower, which blows the fumes over a fin-type condenser.

Next fresh air is drawn in the blower and forced through to deordorize the garments. A lamp is finally lighted to signal that the cycle is complete.

A safety interlock makes it impossible to turn on the extractor and the washing motors at the same time, or to open the doors with motors running. A water-pressure governed steam valve on the still prevents the solvent boiling away.

The cabinet is made of steel plate with welded seams. The entire machine is designed to secure simplicity of control, minimum maintenance and floor space, with appearance in keeping with the better class establishments.

▼ ▼ ▼

Automatic Control of Cutting Speed

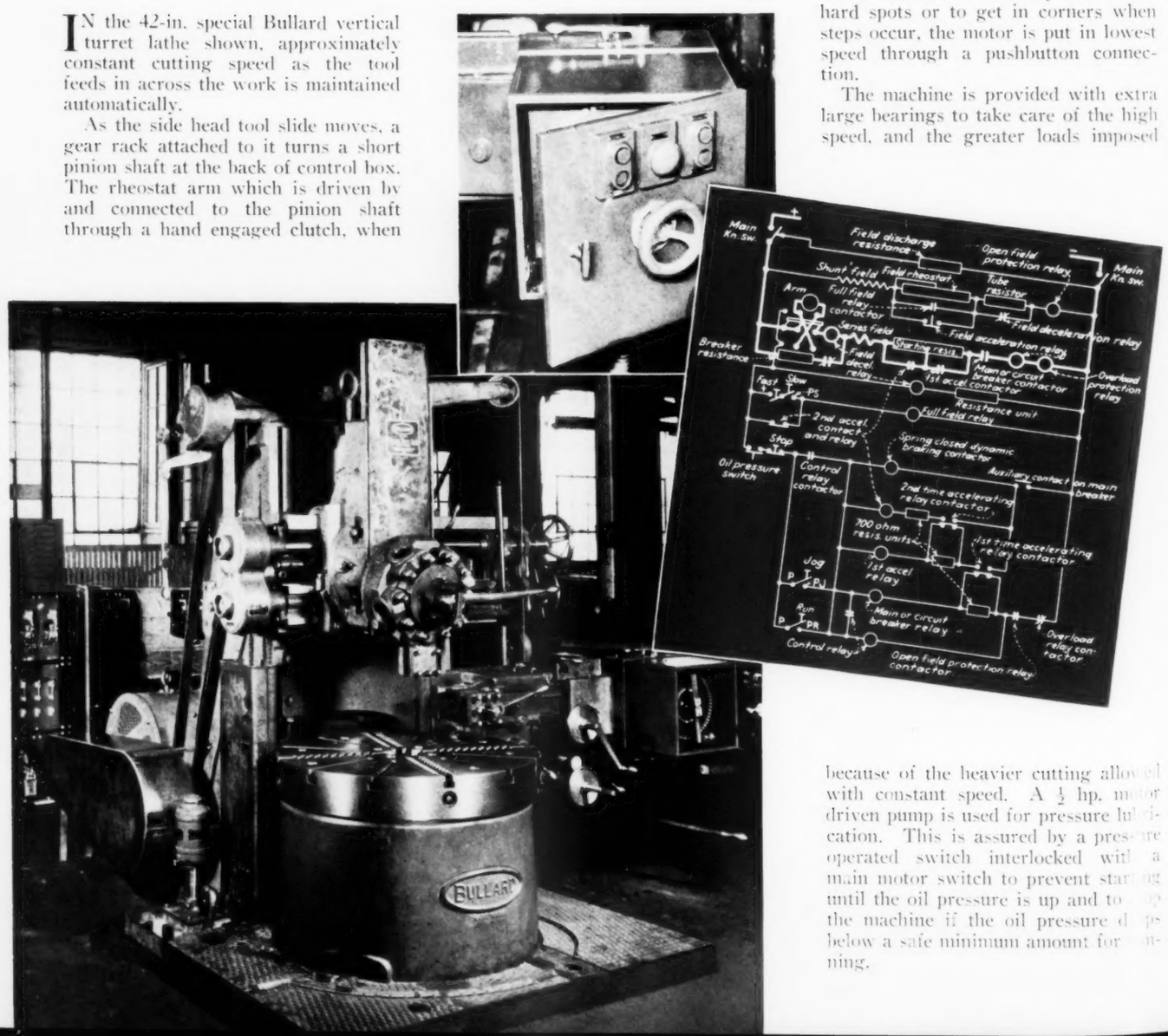
IN the 42-in. special Bullard vertical turret lathe shown, approximately constant cutting speed as the tool feeds in across the work is maintained automatically.

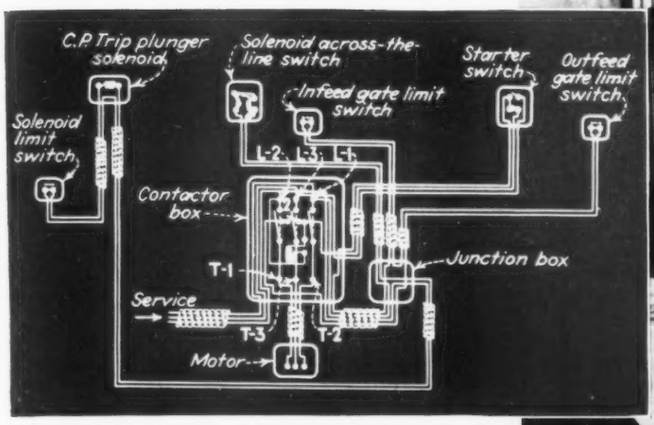
As the side head tool slide moves, a gear rack attached to it turns a short pinion shaft at the back of control box. The rheostat arm which is driven by and connected to the pinion shaft through a hand engaged clutch, when controlling the speed of table changes the rheostat setting. This varies the resistance in the shunt field of the Crocker-Wheeler 25 hp. 230 volt, d.c. driving motor. Decreasing the field resistance as the tool feeds into a smaller diameter increases the r.p.m. keeping the cutting speed approximately constant. The control is calibrated in inch markings corresponding with the diameter of the work at the point of tool contact, or circle where cut is being made.

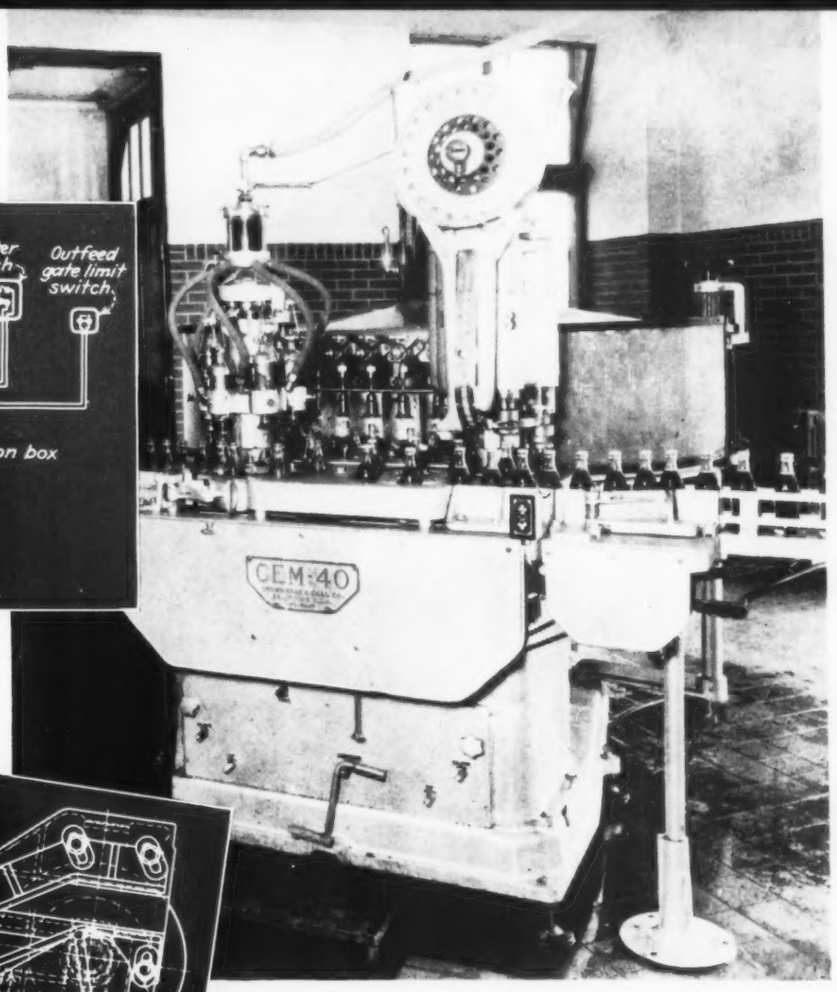
The drawing shows the wiring diagram. An Electric Controller & Manufacturing Company's motor field rheostat, and magnetic and dynamic-braking starter are used for controlling.

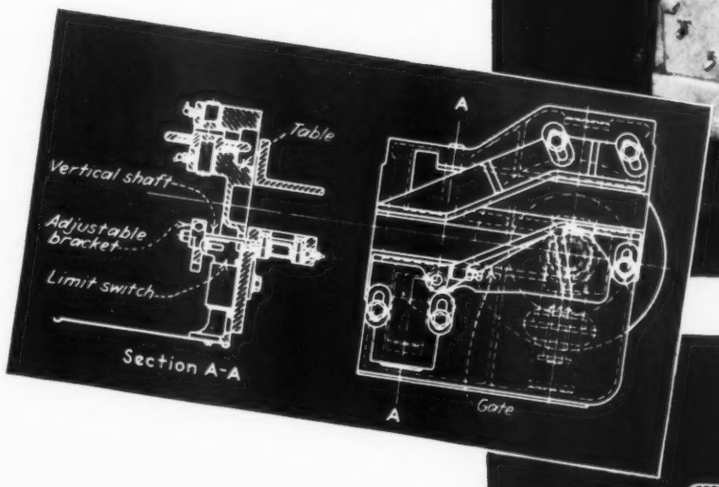
This machine has table speeds up to 150 r.p.m., which is twice that of the standard machine. A standard gear box provides twelve changes, and is marked to show the table r.p.m. and cutting speed. Gears are changed quickly to suit work size and material. An inching relay is provided for slow speed when setting up and chucking work. When it is necessary to machine hard spots or to get in corners when steps occur, the motor is put in lowest speed through a pushbutton connection.

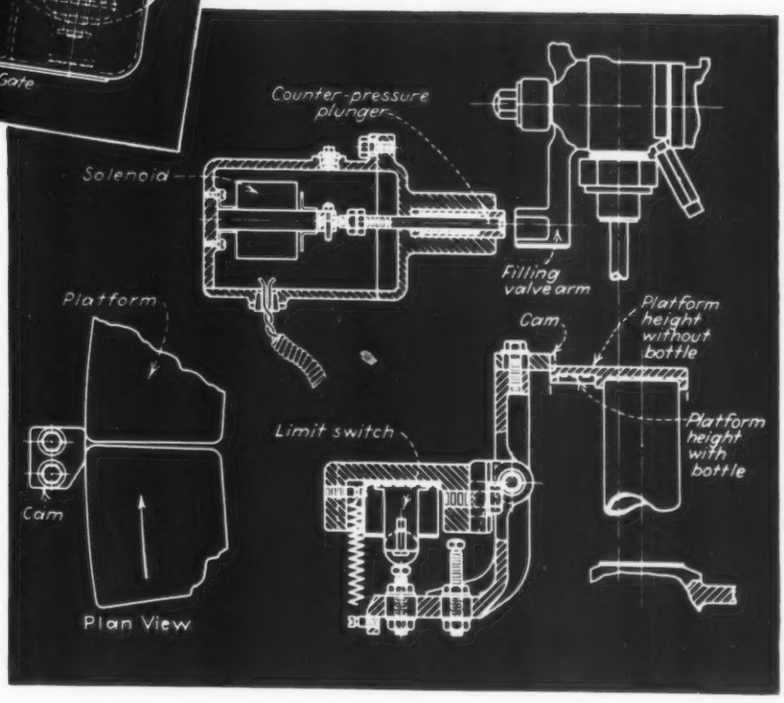
The machine is provided with extra large bearings to take care of the high speed, and the greater loads imposed because of the heavier cutting allowed with constant speed. A ½ hp. motor driven pump is used for pressure lubrication. This is assured by a pressure operated switch interlocked with the main motor switch to prevent starting until the oil pressure is up and to stop the machine if the oil pressure drops below a safe minimum amount for running.











Electrical Devices as Safety Controls

ELECTRICAL devices control the mechanical operation of this syruping, filling and crowning machine, built by the Crown Cork & Seal Company. The wiring circuit is shown in the diagram. Cams and limit switches provide the protective features.

Driven by a 1½ hp. constant-speed internal-brake motor, the machine has a capacity of from 44 to 128 bottles per min. Mounted on an adjustable sliding carriage, the motor has keyed to its shaft a variable diameter Reeves pulley which drives a speed reducer. To vary the speed, the sliding motor base is moved by a screw rotated by a detachable crank handle.

All moving parts of the machine are actuated by a train of gears connected with the reduction unit. The in-put shaft of the reducer is extended and in conjunction with a crank arrangement, provides manual means to inch the machine when setting the cams.

At the junctions of the conveyor and the rotating dials are gates, each with a vertical shaft extending through the table. On the end of each shaft, see diagram, is an adjustable bracket, projecting outward, on the face of which is a radial cam which, upon movement, trips a limit switch. A bottle improperly entering or leaving opens the gate and rotates the shaft bracket cam, this depresses the limit switch and stops the machine. After correcting the trouble, the gate is returned to its proper position by a spring, and the machine again started by pressing the switch button.

As the filling unit revolves, the bot-

tle lift cylinders are lowered as they approach and elevated as they recede from the table. As shown by the diagram, an empty bottle lift cylinder travels at a higher level than one carrying a bottle and contacts a cam, the movement of which releases a depressed limit switch roller which completes a circuit energizing a solenoid.

The counter-pressure plunger is pulled inward by the solenoid, out of the path of the filling valve arm, making the filling valve inoperative. The mechanism will stand in this position as long as the platforms carry no bottles.

A platform with a bottle does not strike the cam but passes under it, allowing the cam to depress the limit switch roller enough to break the circuit, de-energizing the solenoid. A spring is then free to project the counter-pressure plunger outward into the path of the filling valve arm in position to trip it. This mechanism in conjunction with other valve tripping mechanisms, is adjustable for any desired height of bottle.

▼ ▼ ▼

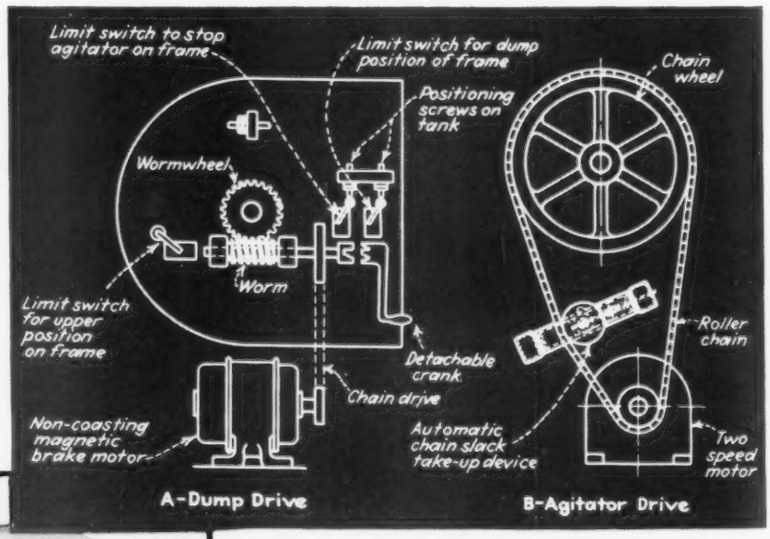
Automatic Timers for Controlling Mixing Periods

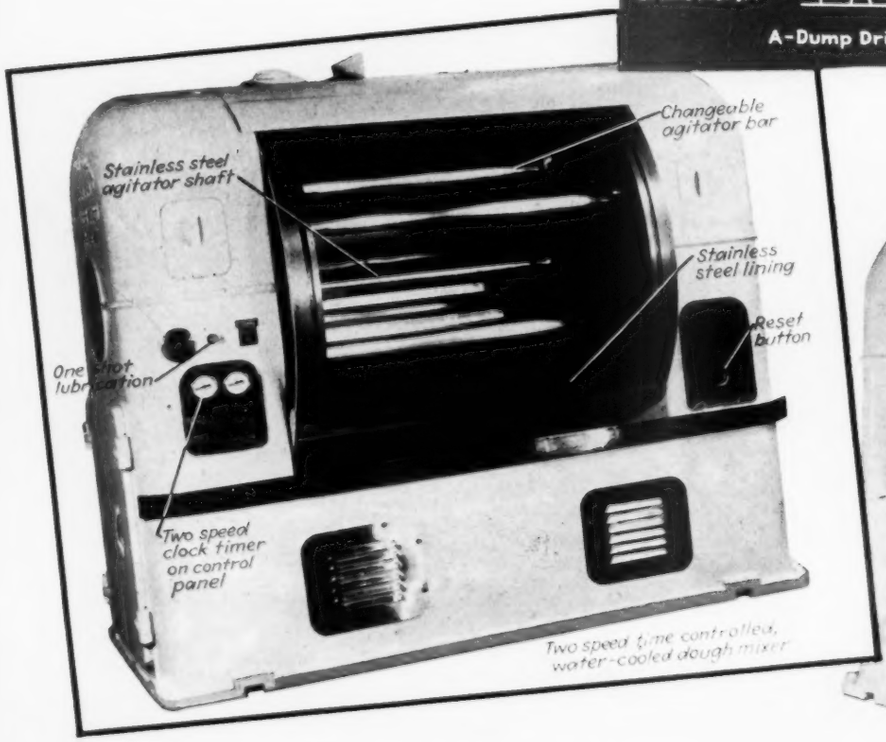
TWO clock driven timing switches eliminate the human element in the operation of the J. H. Day dough mixer equipped with Cutler-Hammer motor controls. Accurate timing of slow and fast mixing periods is essential for best results.

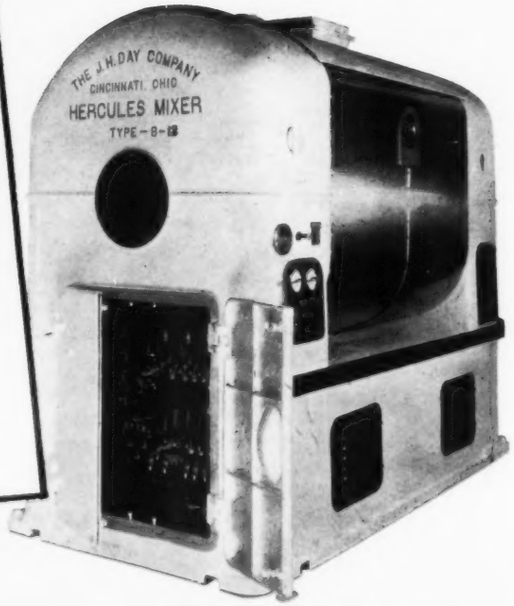
To control the mixing time, Walser timers are built into the pushbutton two-speed control panel at the left of the mixer frame. These are set, one for the initial slow speed and one for the final fast speed mixing periods. After the ingredients to be mixed are weighed out and poured into the tank, the machine is started by pressing the "SLOW" button. At the proper intervals the timers make electrical connections with relay contactors in the agitator-driving motor circuit, automatically changing the r.p.m. of the two-speed geared-head motor from slow to fast. Later at the end of the total mixing period the timers stop the motor automatically.

A hardened steel roller chain which is automatically lubricated connects the driving motor directly to the agitator shaft. An automatic slack adjuster as shown at *B* provides constant uniform chain tension.

At completion of the mix, the "DOWN" button for the dump motor is pressed, rotating the mixing tank about 90 deg. to the dump position, through a chain and worm drive. For safety, as the tank begins to rotate, a limit switch is released, thereby stopping the agitator motor, after which the agitator can be only inched along by pushbutton control when the tank




Changeable agitator bar
Stainless steel agitator shaft
Stainless steel lining
Reset button
One shot lubrication
Two speed clock timer on control panel
Two speed time controlled, water-cooled dough mixer



is open. A built-in magnetic brake on the motor causes it to stop instantly. When the tank reaches the lowest position movement is stopped by a roller arm limit switch. The tank, when the "UP" button is pressed, is rotated back to the mixing position and again stopped by another limit switch. The self-locking worm drive holds the tank rigidly in the operating position.

To dump the tank, should the dump motor fail, a detachable hand crank shown at *A* is inserted which engages the worm shaft.

Inside the housing are two auxiliary pushbuttons. One is for manual control of the machine without using the timers. The other is for shutting down the entire machine so that it cannot be operated until the control box door is opened and a switch pressed.

The mixing tank is water-jacketed for cooling. To indicate the temperature of the dough, a built-in dial type thermometer is mounted flush with the surface of the tank. The thermometer bulb is made of rust-proof steel insulated with bakelite.

Agitator bars of different surface shape and clearance for various mixing requirements are furnished. They can be interchanged quickly.

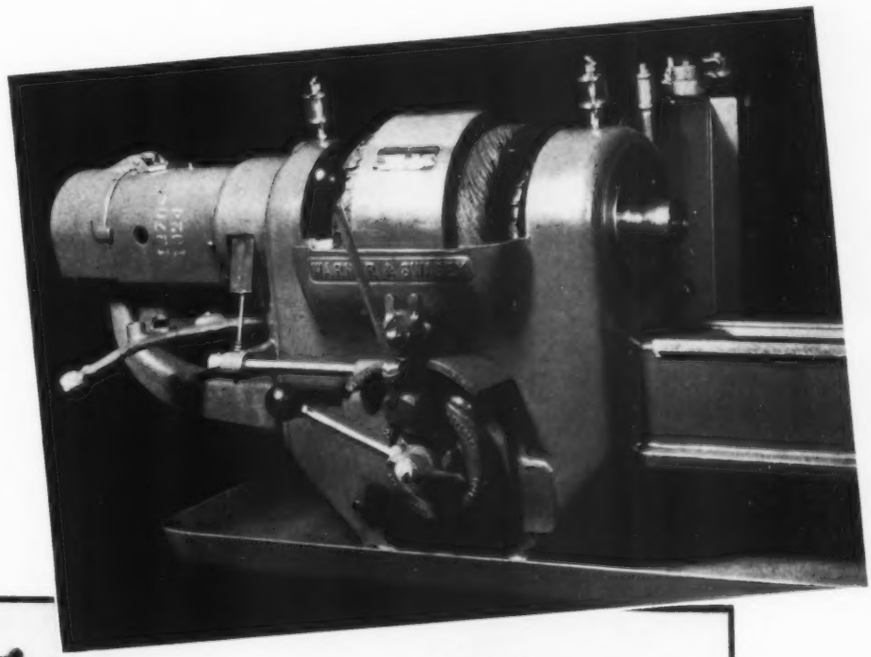
Much attention has been given to appearance. Ventilated cast-iron base and frame, smooth surfaces, rounded corners; tank lining, tank cover, and inspection opening plates all of stainless steel, bespeak sanitary construction. Other features are: grease sealed bearings, no stuffing boxes, and one-shot lubrication.

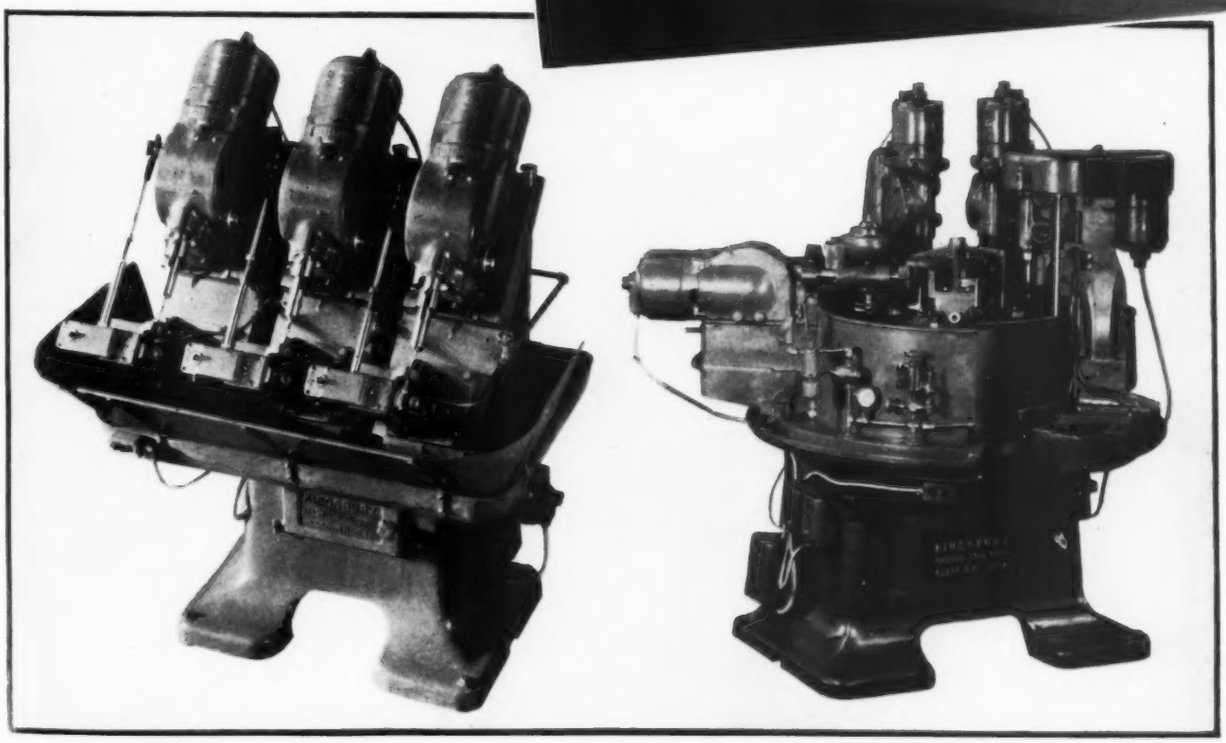
Typical Motor Applications for Built-In Drives

ALONG with built-in controls and automatic operation is the problem of motor mountings. The illustrations on this page indicate what can be accomplished by making the motor a part of the machine. Both flange mounted and built-in designs are shown.

It is not to be assumed that built-in motors are always the ultimate goal. In many instances a standard foot-type motor is preferable. Or the standard flange type mounting may be better than a built-in design. In each instance the relative simplicity of the design, ease of replacement, speed-change requirements, space limitations and similar factors will guide the designer in making his selection of the style that suits a machine.

It is evident that the trend is strongly toward flange-mounted and built-in motors, especially where the drive is directly off the motor shaft. But not all machines lend themselves to this type of mounting.





Determining Quickly the Storage Stability of

In many instances trouble has been caused by deterioration and hardening of grease in anti-friction bearings while standing idle over long periods, either in the machine or while the greased bearings were in storage. A quick and simple test to enable the selection of a grease possessing maximum stability can prevent this. Such a test method is described in this article and comparisons of test results with the stability of grease under normal storage conditions are given.

LUBRICATING greases in machine parts that are unused for long periods of time occasionaily undergo oil separation, turn rancid and harden sufficiently to prevent free movement of the rotating parts. It is well known that some lubricating greases are more stable than others. Therefore, the selection of greases that will not undergo such changes, that is, have good storage stability, is obviously an important problem to the engineer responsible for specifying lubricants for units such as gears and transmissions, electric motor bearings, ball and roller bearings, sleeve bearings and similar applications.

The term "storage stability" is used in this article to apply only to lubricating greases in contact with machine parts and in the normal amounts usually applied for lubrication. It does not refer to the stability of lubricating greases stored in drums, barrels or tubes, prior to use. Stability of greases in original containers is usually satisfactory so long as the grease is sealed against contact with air.

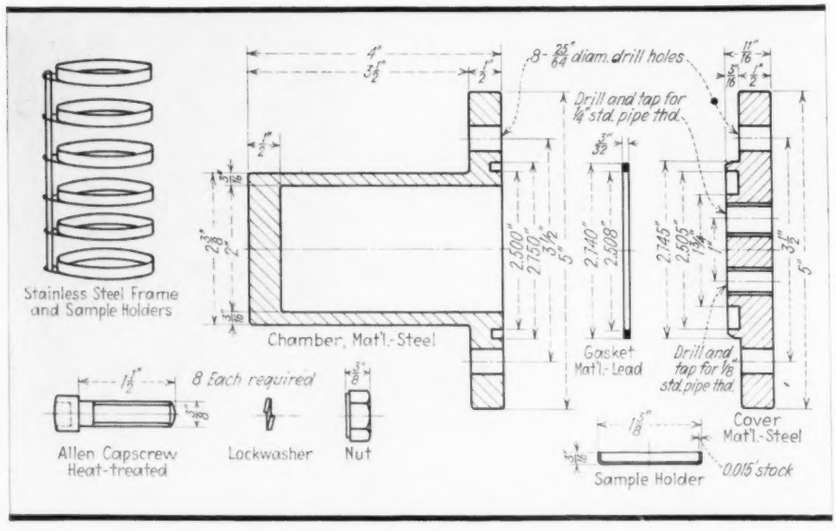
Changes taking place in grease stored in machine parts proceed slowly, being influenced by such variables as temperature, humidity, amount of air circulation and the kind of metal or metals in contact with the grease. Employing only those test methods heretofore available, these variable conditions have made it difficult to select the lubricating greases likely to possess satisfactory storage stability characteristics. (See reference 7 at end of article.) Nor is it practicable to determine the stability of greases by protracted aging tests requiring from six months to three years for completion.

The need for an accelerated stability test has long been evident. To meet this need, the Norma-Hoffmann Bearings Corporation sponsored researches at the Pennsylvania State College and later conducted extensive tests in its own research department. This resulted in the development of an accelerated test which predicts the storage life of soda-base lubricating greases.

Grease may be defined as a stable gel made from lubricating oil and a soap, processed in the usual manner by the reaction of fats or fatty acids with a suitable alkali under controlled conditions of temperature, pressure and agitation. The lubricating oils, soaps, fats, fatty acids and the by-products of soap making, likely to be present in any well made grease, are composed of great numbers of complex chemical compounds. By their nature, they are difficult to control as regards uniformity and moreover do not lend themselves readily to individual analysis. Difficulties arise when attempts are made to follow the progress of deterioration by analyzing for such reaction products as peroxides, aldehydes and acids.

Accelerated oxidation tests are now being successfully applied to the study of the stability of mar-

Fig. 1—Details of parts for absorption bomb for quickly testing the storage stability of greases



Lubricating Greases

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W. A. LUTZ, *Chemical Engineer*
Research Laboratories,
Norma-Hoffmann Bearings Corporation

Fig. 2—Test equipment consists of the bomb submerged in an electrically heated oil bath that is stirred continuously and has its temperature controlled automatically

TABLE I—PROPERTIES OF TEST GREASES

	A	B	C	D
Calcium Soap, per cent.....	nil	nil	1	1
Sodium Soap, per cent.....	23	15	12	27
Oil-viscosity 100 deg. F. saybolt seconds.....	400	500	700	300
ASTM Worked Consistency....	240–280	310	280	240
Flow Point deg. F.....	325	340	377	374
Free Acid as Oleic per cent.....	nil	2.0	nil	nil
Free Base as NaOH per cent...	0.16	nil	0.12	0.58

TABLE II—RELATIONSHIP OF ACCELERATED OXIDATION TEST TO ACTUAL LONG TIME AGING TEST

Grease	Induction Period Oxygen Absorption Test	Time Required for Breakdown
A	23 hours	2 months
B	50 "	3 "
C	500+ " (no break)	Satisfactory at 15 months
D	280 "	" " " "

organic materials, for example: natural fats, gasoline, white oil, rubber, and others. (See references 1, 2, 3, 4 and 5 listed at the end of this article.) Studies made on vegetable oils, fats, gasoline and similar materials, by means of oxygen absorption methods, disclose that oxidation usually progresses in two definite steps. The first step called the induction period, is characterized by a slow reaction rate with small changes in the chemical properties of the materials under test. The end of the first step and the beginning of the second period is defined by a sharp increase in reaction rate, with corresponding changes in chemical and physical properties. The length of time of the first or induction period is considered a satisfactory measure of the stability of the materials under test.

Since it has been observed repeatedly that lubricating greases when subjected to long time storage tests break down in two definite periods, as do fats, it was considered probable that they would likewise lend themselves readily to analyses by means of oxygen absorption methods. Furthermore, it was found that oxygen absorption data could be obtained conveniently on small samples with a sensitivity not attainable by methods involving usual chemical analysis.

The apparatus used for determining the stability of lubricating grease by this oxygen absorption method consists essentially of a steel bomb and a suitable constant temperature bath. For convenience this bath is made large enough to hold several bombs. The bomb is fitted with a suitable valve for flushing and filling with oxygen and is equipped with a pressure gage to indicate drops in pressure resulting from the absorption of oxygen by the sample of grease that is put in the bomb. Grease samples weighing 13 to 15 grams are spread in a uniform layer; not more than 0.125 in. thick, over the surface of holders of glass or holders made of metal similar to that which is likely to contact the grease in actual service. The exact weight of grease is determined by weighing the holders before and after applying the grease. The cups holding the grease samples are suspended on 18-8 stainless steel wire frames. Closure of the bomb is effected by bolting down the cover plate, a lead gasketed tongue and groove joint assuring pressure tightness.

When the bomb has been assembled for testing, it is flushed by filling it repeatedly with oxygen and allowing the oxygen to escape. This is done at least five times after which the bombs filled with oxygen to approximately the pressure to be used, making allowance for the pressure increase that will occur when the bomb is heated to the testing temperature of 175 deg. F. The bomb is then immersed in the constant temperature oil bath which is provided with agitation and is thermostatically controlled to maintain the temperature within ±0.5 deg. F. of the desired figure. When the bomb reaches constant temperature, usually within two hours, the oxygen is gassed off to the exact pressure selected for the start of the run.

During the test the pressures are recorded every two hours. From the drop in pressure there is calculated the c.c. of oxygen absorbed, the volume calculations being reduced to atmospheric pressure. These are plotted

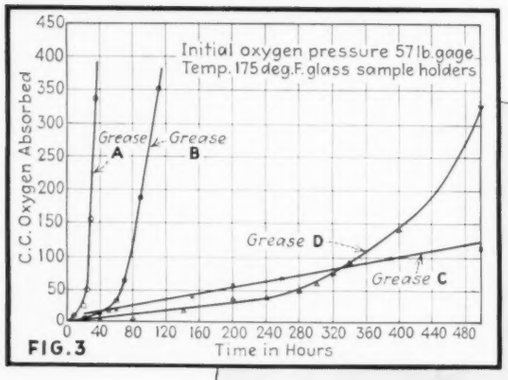


FIG. 3

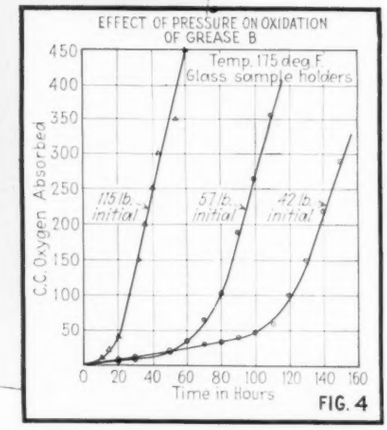
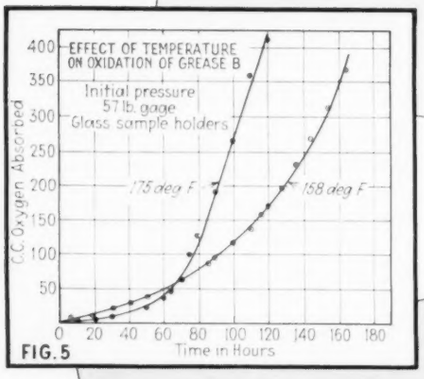
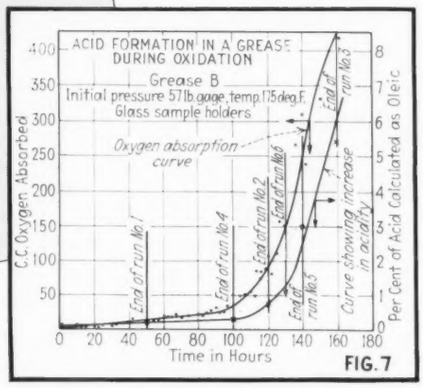


FIG. 4


EFFECT OF TEMPERATURE ON OXIDATION OF GREASE B
Initial pressure 57 lb. gage
Glass sample holders
175 deg. F.
158 deg. F.
C.C. Oxygen Absorbed
Time in Hours
FIG. 5

Volume of oxygen absorbed is calculated from the drop in pressure. These curves are typical for the conditions to which they relate


ACID FORMATION IN A GREASE DURING OXIDATION
Grease B
Initial pressure 57 lb. gage, temp. 175 deg. F.
Glass sample holders
Oxygen absorption curve
End of run No. 1
End of run No. 2
End of run No. 3
End of run No. 4
Curve showing increase in acidity
C.C. Oxygen Absorbed
Per Cent of Acid Calculated as Oleic
Time in Hours
FIG. 7

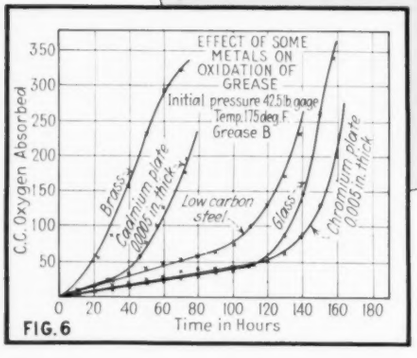


FIG. 6

against time, either on standard coordinate paper or on logarithmic paper. A sharp break in the time-absorption curve indicates the end of the induction period.

In Table I are given the chemical and physical properties of some of the greases used in tests. An example of the curves plotted from these oxygen-absorption tests of soda-base greases is shown in Fig. 3. These curves show clearly the wide variation in resistance to oxidation to be found between typical commercial greases.

To provide a basis for comparison of test results with stability under normal storage conditions, these same greases were packed in bearings that were allowed to stand exposed in a storage room. The bearings were examined at frequent intervals over a period of fifteen months. A noticeable rancid odor, evidence of separation of the oil from the soap, or a marked increase in roughness noticed when the bearings were turned by hand, were considered indications that the tested grease was no longer satisfactory as ball bearing lubricants. This practical test not only indicates the trend exhibited by these greases, but also establishes whether or not there is any relation between the oxygen absorption test for stability and the stability of the grease under normal storage conditions. The evidence is conclusive. As shown in Table II, greases *A* and *B* having the shortest induction periods broke down quickly in normal storage while greases *C* and *D*, with longer induction periods, had reasonable storage life without perceptible evidence of breakdown.

Some of the factors found to have an effect on the oxidation of grease when tested by means of the accelerated oxygen absorption method are oxygen concentration, the temperature at which the oxidation test is run and the catalytic agents present in the form of metals in contact with the grease. The effect of increasing oxygen pressure is shown in Fig. 4 to be a noticeable shortening of the induction period. Since the induction periods are approximately inversely proportional to the square of the pressure, it is obvious that in order to secure reproducible results an accurate pressure gage must be used. Gages having errors of less than $\frac{1}{2}$ of 1 per cent have been found satisfactory. Initial pressures from 42 to 115 lb. per sq.in. have been used and 110 lb. per sq.in. pressure has been selected for routine testing of stable greases. At this initial pressure an induction period is developed in most commercial greases within a reasonably short time and without sacrificing sensitivity. Lower pressures are used when it is desired to lengthen the induction period in order to get more precise results, as, for example, when studies are made on the effect of catalysts or antioxidants on an unstable grease.

The effects of a higher test temperature on the oxygen absorption curve are shown in Fig. 5 to be an in-

crease in "sharpness" at the point of breakdown at the end of the induction period, and a shorter induction period. The temperature of 175 deg. F. was selected as standard for the test procedure as now carried out, since at this temperature the vapor pressure built up from the small amounts of moisture present in most soda-base greases is not sufficient to affect the results. Furthermore, the temperature of 175 deg. F. is close to the maximum temperature at which most soda-base greases can be used in service. The test method as described has been applied only to the high melting point soda-base greases commonly employed for ball bearing lubrication. Lower temperatures will no doubt have to be used when testing lime-soap or other greases that have melting points lower than the soda-base greases.

Greases in stored machine parts are known to have their stability affected more by some metals with which they come in contact than by others. The test procedure lends itself nicely to such a study by using sample holders made of the metal. The absorption curves in Fig. 6 show the effect of some common metals on a typical grease having poor storage stability. Other tests show that greases do not always follow this same order of contact stability, so that it becomes essential to conduct stability tests on greases in contact with the metals with which they are used in service. An investigation of the catalytic effect of a number of metals and alloys is now being made.

It has been observed that greases show an increase in acidity when they deteriorate in normal storage and short time tests have been reported in which the increase in acidity has been used to indicate the stability of the grease. (See reference 6.) It was of interest therefore to follow the progress of oxygen absorption with changes in acidity. A number of absorption runs on grease *B* were interrupted in progressive time intervals and acidity determinations made. The results are given in Fig. 7 and show that very little increase in acidity occurs during the induction period, but that acidity increases rapidly as soon as breakdown occurs, shortly after the completion of the induction period. These data also illustrate how consistently the absorption values may be reproduced between runs for any one set of test conditions. As shown in Fig. 7 all the absorption values for six separate runs fall closely on a common curve.

Most greases examined by the oxygen absorption method have shown the typical induction period with its slow rate of oxygen absorption, but some exceptions to this have been found. When quantities of readily oxidized materials are present in the grease, the induction period is not evident, but a reverse condition is found in which the rate of absorption is very fast at first, gradually diminishing with time. Such greases have poor storage stability characteristics, as might be expected.

Summarizing, the storage stability of lubricating greases may be determined by measuring the rate of oxygen absorption and observing the length of time of the induction period. It will be affected by the initial pressure, bath temperatures and metals serving to catalyse and speed up the reaction. For soda-base greases a pressure of 110 lb. per sq.in. and a temperature of 175 deg. F. and using steel and brass sample holders to catalyse, the reaction produces a breakdown of the samples in from one to twenty days, or more, depending upon the stability of the grease. No absolute relationship between long time storage stability and accelerated tests has been determind, but it has been estimated that the combination of oxygen concentration and the temperature used have accelerated the normal oxidation rate in storage by 50 to 100 times. In comparing the results of accelerated tests with long time storage tests, using anti-friction bearings as grease sample holders, the results have correlated consistently.

An accelerated test method such as described makes it possible for the user to specify definite storage stability characteristics for lubricating greases, either in terms of the number of hours for the induction period or the rate of oxygen absorption in c.c. per hr. during the induction period. The method permits a reasonably rapid check on shipments for uniformity between batches, which is one of the important considerations in providing the best possible lubricant for anti-friction bearings. It also provides a means for the grease makers to control and improve their raw materials and processes so as to produce a more stable and uniform finished product.

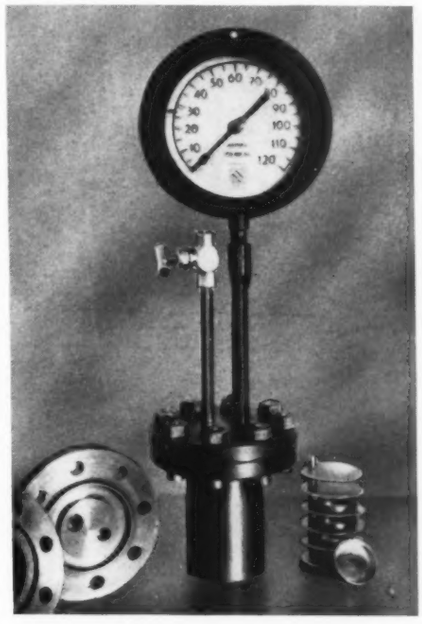


Fig. 7—One of the oxygen absorption bombs used for testing the storage stability of greases, assembled and ready for the test

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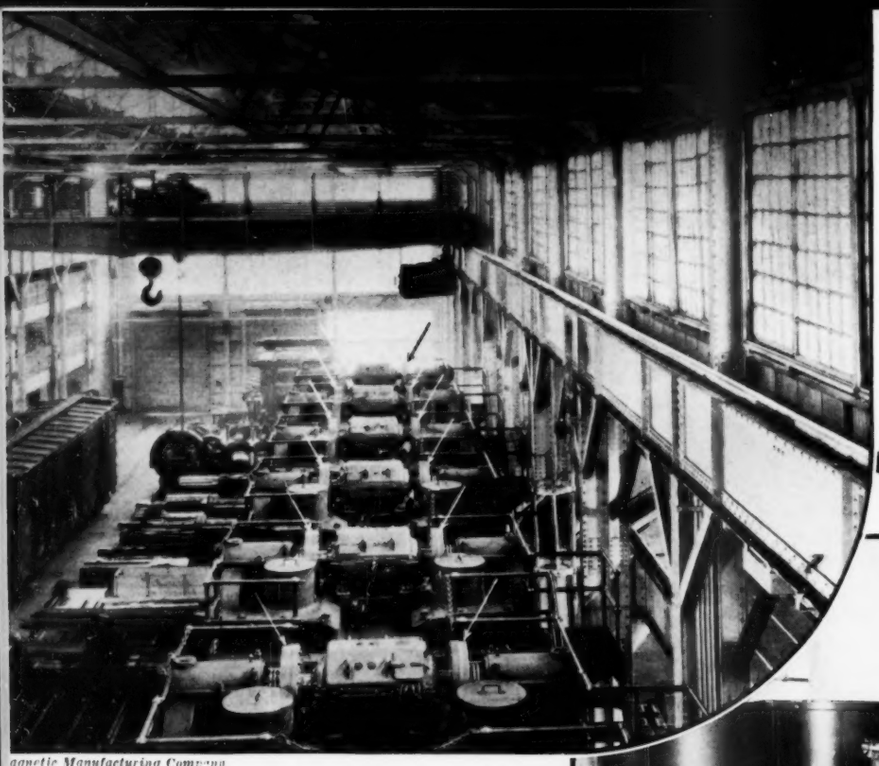
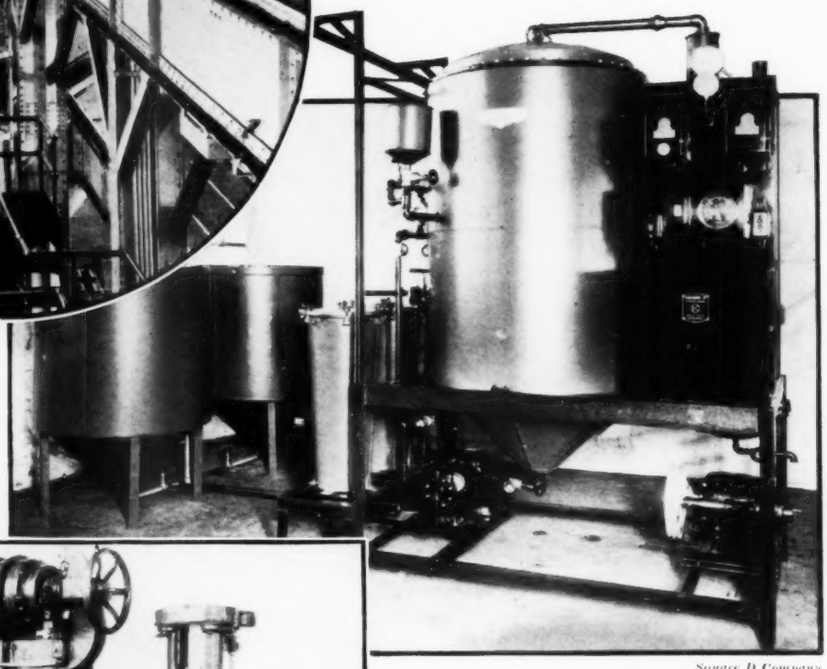
(7) James I. Clower, "American Lubricating Greases." Bulletin of the Virginia Polytechnic Institute. Vol. XXIX, No. 1 (1935).

Electrically



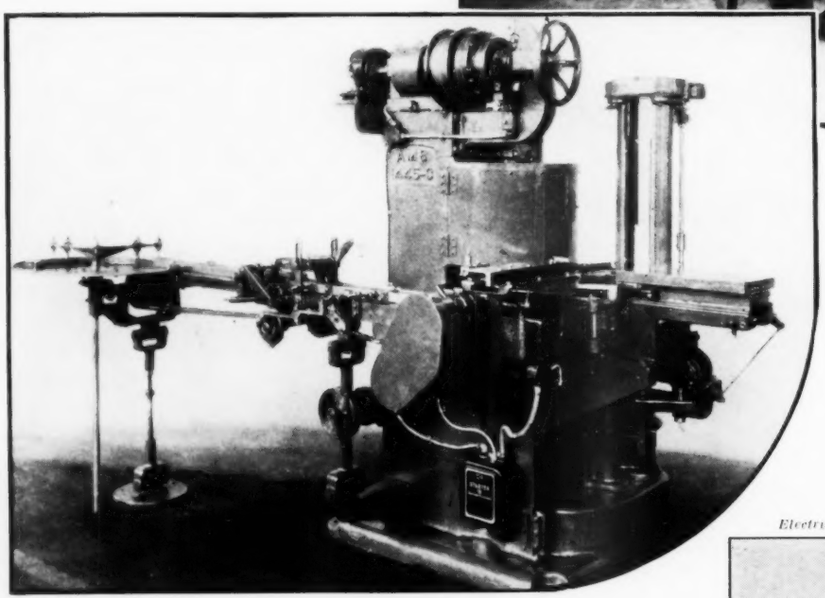
agnetic Manufacturing Company

Magnetic clutches can also be used for heavy duty as in these Stearns clutches for the screw-down drives for rolling mills. Arrows indicate clutches



Square D Company

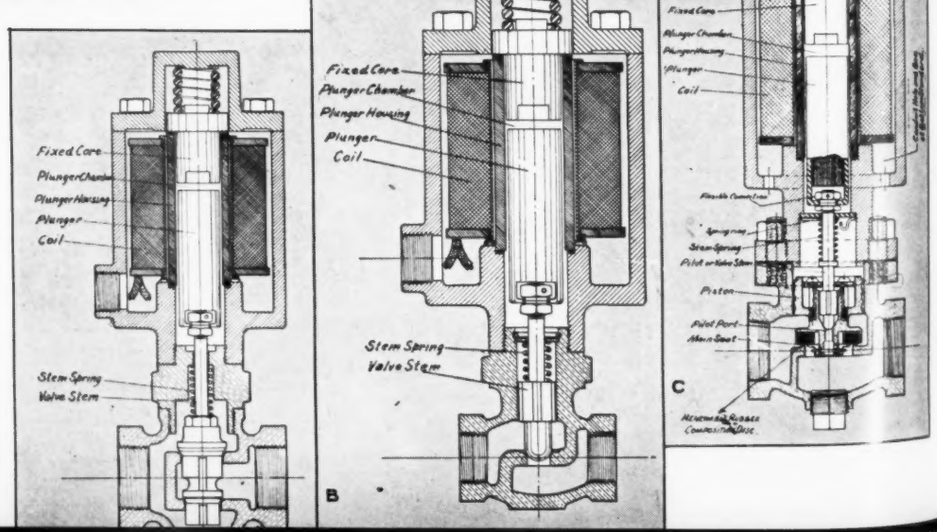
Automatic control of this oil filtering machine manufactured by Hopkins Tull Machinery Company includes an automatic vacuum switch in addition to the pushbutton control of the two pump motors



Cutler-Hammer, Inc.

Max Ams can making machine equipped with magnetic clutch and solenoid brake for automatic stopping

Electric Valve Manufacturing Company



Typical solenoid operated valves. A—balanced valve for high pressures. B—Needle-type valve. C—Pilot operated wherein opening of the pilot valve causes main valve to be actuated by fluid pressure

Operated Clutches Brakes and Valves

DISK-TYPE magnetic clutches are relatively old. But it has been only in the past few years that they have come into more general use. One of the more recent new applications has been for the screw-down drives on rolling mills, as illustrated in the accompanying picture. Here the main advantage is simplicity of remote control.

One manufacturer of tapping machines uses magnetic clutches for their slip feature. On drives involving high inertia or starting loads, they have the advantage of gradual pick-up of load which keeps down the inrush current in the motor. Where frequent starting and stopping is required, it may be better to use a magnetic clutch instead of stopping and starting the motor, especially where there would be a high in-rush current in the motor. As on the Monarch lathe (*see P. E., Nov. 1934*) magnetic clutches can be used for controlling the running of a particular unit of the machine, the main driving motor running continuously.

By holding the one member stationary, a disk type magnetic clutch can be used as a brake. This makes a compact arrangement. In the design of an assembling machine, a magnetic brake and clutch are used together. An electrical contact simultaneously disengages the clutch and applies the brake, stopping the machine almost instantly. In another design, shown here, a disk type magnetic clutch and solenoid brake are used.

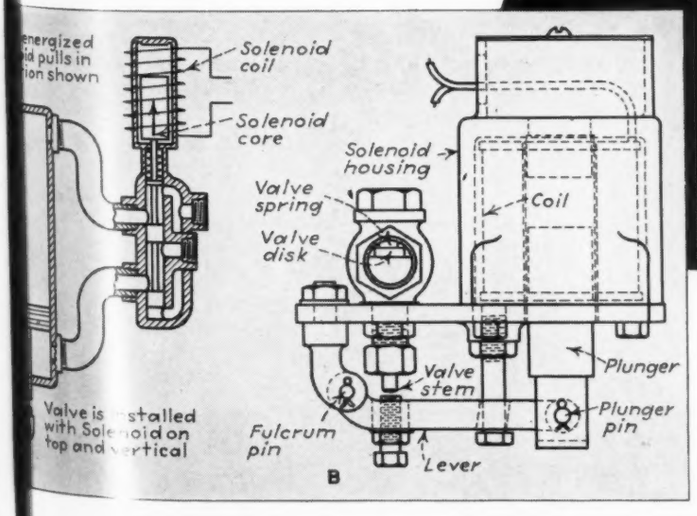
According to the chief engineer of a manufacturer of automatic machinery, more attention is being paid to magnetic clutches and brakes primarily because speeds are increasing and parts are being designed heavier to withstand the higher speeds. Both contribute to higher inertia forces. For this reason the mechanical devices for safety stops are often becoming inadequate, for which reason more attention is being paid to the possibilities of magnetic clutches and brakes. Their use in connection with photo cells is also being developed.

In processing machines such as the garment cleaning unit described in this number, it is necessary to control the flow of fluids. An almost endless variety of solenoid valves have been developed for such purposes.

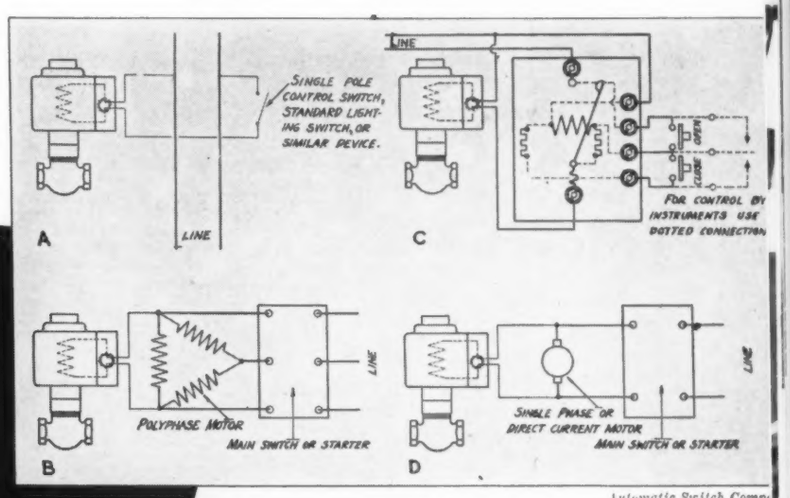
Solenoid valves usually close by spring pressure and are opened by the pull of the solenoid, although they are also designed to be closed by the pull of the solenoid. The reason for this is that usually the valve should be closed when the power is off and the machine is not running.

In the accompanying diagram is shown the principal methods of connecting solenoid valves. Herewith are also shown a few of the various types of valves available, as indicated in the captions.

Through the use of electrically operated brakes, clutches and valves in connection with proper control devices, almost any machine can be made entirely automatic in its operation.



At **A** *is a 4-way valve manufactured by Automatic Switch Company for controlling a hydraulic cylinder.* **B** *is a lever operated valve made by Electric Valve Manufacturing Company*



Automatic Switch Comp

Four ways of connecting solenoid valves. **A**—*Across line.* **B**—*For 3-wire momentary contact.* **C** *and* **D**—*Valve and motor controlled from same switch*

Governor-Controlled Fractional-Horsepower Motors

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General Electric Company, Fort Wayne, Ind.

For applications not requiring large horsepower and where the running speed must be kept constant, governor-controlled universal motors have a number of unusual characteristics as given in this article. The types available, favorable operating conditions and the inherent limitations are explained in detail

CENTRIFUGALLY operated contact mechanisms for controlling the electrical circuit of motors to govern speed are not new. They have been used in a few highly specialized fields, such as in communication and temperature-recording work, for more than twenty years. In these fields, the necessity for motors operating with very small speed variation led to the development and application of contact governors. Although this is of interest historically, it should also be noted, parenthetically, that today the trend of these particular applications, wherever alternating current sources of power supply at constant frequency are available, is toward synchronous-induction motors which run at a speed determined by the frequency of the power supply.

Governor-controlled shunt-wound direct-current motors, because of their limitation to direct-current use, are not of general interest. Their speed is controlled by governor-controlled contacts. As indicated in Fig. 1, opening and closing of the contacts controls the resistance in the shunt field, thereby controlling the motor speed.

Governor-controlled series-wound motors, which operate on alternating current, as well as on direct current, have created a great deal of interest in the last few years and this article will be concerned mainly with motors of this design.

Governor-controlled series-wound universal motors for adding and calculating-machine applications were introduced in 1928 and met with almost immediate acceptance. In 1932 they were applied to portable motion-picture projectors and in 1933 to typewriters. Today by far the greatest percentage of adding and calculating machines built in the United States use governor-controlled motors.

When applied to series-wound motors, governors are connected in series with the motor and the contacts make and break the motor circuit to control the speed. There are several types of these governors.

The center-contact type of governor shown in Fig. 2 has one stationary contact located axially with respect to the shaft. In the motor shown the contact is mounted on the frame of the device into which the motor is incorporated. The rotating contact and the weight system which operates it are mounted on a collector carried on the motor shaft. Current is carried to the rotating contact by a collector brush. This governor design is most suitable for operating speeds between 2,000 and 3,000 r.p.m. It is possible on a given governor design to adjust the motor speed over a range of approximately plus or minus 15 per cent while the motor is running. Speed regulation of 5 per cent or less is obtained with normal line-voltage variations. The contacts operate with a wiping action, a desirable feature when operating on direct current. This type of governor is used chiefly on start-stop applications.

Governors of the rotating-contact type are shown in Figs. 3 and 4. In this type of governor both contacts rotate with the shaft. On the designs shown, both contacts are carried on flat springs mounted on a disk of insulating material which carries two collector rings on the opposite side. Each contact makes electrical connection with a collector ring and collector brushes complete the circuit to the contacts. Only the outer contact is centrifugally operated. The position of the inner contact determines the speed at which the contacts open and, in the case of the governor in Fig. 3, the adjustment is made by stopping the motor and adjusting the setscrew shown.

On the governor shown in Fig. 4, the position of the inner contact can be adjusted while the motor is running by a mechanical linkage which bears against a stop that is movable axially with respect to the shaft. This is a versatile governor design suitable for a wide range of operating speeds and adjustable over a wide speed range. Speed regulation of from 3 to 5 per cent, depending upon operating conditions, may be obtained with normal line-voltage variation. Under the best conditions of operation with a constant load, the speed variation can be held to less than plus or minus 1 per cent with a plus or minus 10 per cent variation in line voltage.

The circuit usually employed with governor-controlled series-wound motors is illustrated in Fig. 5, and Fig. 6 shows the speed-torque characteristics of a series-wound motor with and without a governor. The

resistor and capacitor which are shown in parallel with the governor contacts are used to obtain a clean break at the contacts, increase their life, and give a smoother operating motor, but may be disregarded insofar as the general principle of operation is concerned.

Upon starting, the motor accelerates as a conventional series-wound motor, the speed of which is determined by the load imposed upon it. Upon reaching a predetermined speed, the governor contacts operate, opening the motor circuit. This cuts off the motor power and the speed drops until the contacts again close and permit the motor to accelerate. This cycle is repeated at high frequency, holding the motor between maximum and minimum speeds. The design of the weight system, the weight of the moving member, the cleanness of the break at the contacts, operating speed of the motor, inertia of the rotor and its connected load, and the ratio of available motor torque to the torque taken by the load—all affect the speed limits between which the motor operates and the variation obtained in the average speed with changes either in load or line voltage.

The governor permits the motor to take power from the line only when needed to carry the load. On light loads, the contacts are open a large portion of the time; on heavy loads, they are closed a large portion of the time. The average motor input is therefore controlled by the load imposed upon the motor. This is a desirable feature in that the motor can be designed for maximum outputs, much in excess of the average power requirements to take care of momentary heavy overloads, heavy starting-torque conditions, and fast acceleration. This action of the governor permits operation over relatively wide voltage variations, for with a given load on high voltage, where the motor has the most output, the contacts remain open a greater part of the time than they do on low voltage where the motor output is reduced. Under this condition the average input and average motor losses do not remain constant but vary less than on most types of motors.

Capacitor Prevents Sparking

In Fig. 5 is shown a capacitor in parallel with the governor contacts. This prevents sparking at the contacts by absorbing the inductive voltage generated when the motor circuit is opened. The capacitor has the disadvantage of discharging a rather heavy current through the contacts when they close.

Resistance in parallel with the capacitor and the governor in Fig. 5 reduces the voltage across the capacitor when the governor contacts open, provides a discharge path for the capacitor and reduces the current change in the motor, thereby reducing the inductive voltage generated in the motor circuit when the contacts are opened. In addition to these desirable features, it is often possible to adjust the resistance value so that the motor will carry a good percentage of the load with

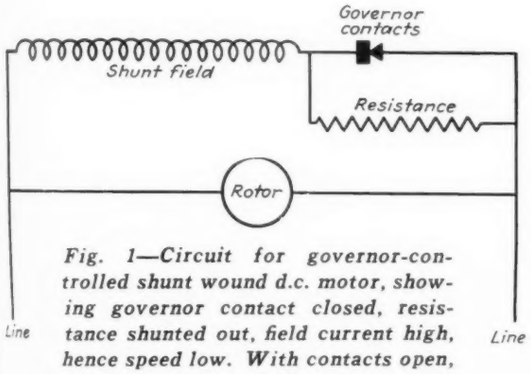
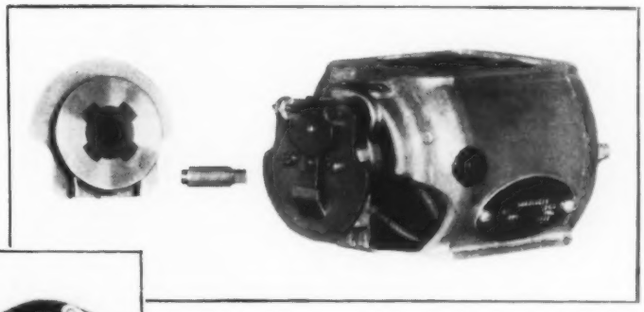


Fig. 1—Circuit for governor-controlled shunt wound d.c. motor, showing governor contact closed, resistance shunted out, field current high, hence speed low. With contacts open, resistance is in, field current low, hence speed high.



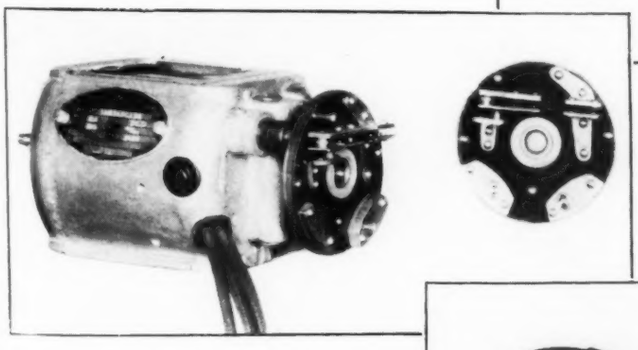


Fig. 2 (Above)—Typical series-wound motor with center-contact governor. Fig. 3 (Left)—Universal or series-wound motor with rotating-contact type governor. Speed can be adjusted when motor is stopped

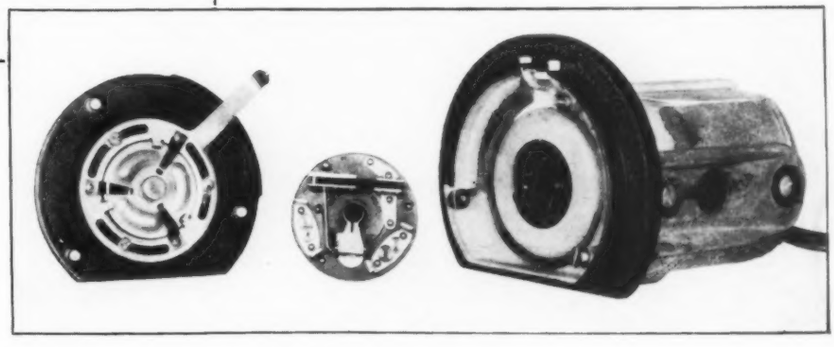


Fig. 4 (Right)—Universal or series-wound motor with rotating-type contact governor. Speed can be adjusted while motor is running

the governor contacts open and the number of operations of the governor contacts is materially reduced and their life increased.

Brush Life

The well-known salient-pole series-wound motor has the highest efficiency at from 5,000 to 8,000 r.p.m., depending upon the frame size, the efficiency dropping rapidly with a reduction in speed. A well-designed motor of this type will have a brush life of from 500 to 1,500 hr. at 10,000 r.p.m. If designed for lower output and lower speed, at 3,000 r.p.m. the brush life may be approximately 4 times that at 10,000 r.p.m. At higher operating speeds, moderate-sized ventilating fans are normally used to obtain the maximum output out of a motor of a given frame size.

A governor makes it possible to use lower operating speeds to extend brush life although this results in a big sacrifice in efficiency and may require a motor of larger size to carry continuous load. This reduction in continuous load capacity does not handicap the motor on applications which have a light average load and require a high maximum output and torque for momentary load conditions or rapid acceleration, for the governor action allows the motor to take only enough power from the line to handle the load.

At lower operating speeds, the life of the governor contacts and the collector become the determining factor in the design. With moderate motor outputs and low operating speeds, governor life of from 2,500 to 5,000 hr. has been obtained on 60-cycle life tests.

Another type of series-wound motor, the compensated-series-wound or distributed-field-winding type, may be used to combat the disadvantage of low efficiency at low operating speeds found in salient-pole series-wound motors, for it has much better efficiency at low speed. This type of motor has its disadvantages, however, for brush life even at low-speed operation is not much better than that of the salient-pole series-wound motor operating at high speed, and the motor is more costly.

One of the desirable features of governor-controlled motors is their ability to operate on direct current as well as alternating-current but when a pair of contacts are used to make and break a direct-current circuit of fixed polarity, the volatilized contact material is carried along the arc from one contact to the other, one contact being eroded and the other built up by the metal transferred. This action is considerably accelerated when one contact is built-up sufficiently to concentrate the arc upon a small portion of the contact surface. The wiping action of the contacts in the center-contact type of governor prevents the build-up of metal on the one contact on direct-current operation and the life on direct current is comparable with that obtained on alternating current. On the rotating-contact type, where the duty cycle is fairly heavy or where the polarity of the circuit is not reversed at fairly frequent intervals, it is desirable to resort to some automatic means to reverse the circuit through the contacts. Then, the problem may center on the life of the polarity-reversing arrangement instead of on governor contact life.

Opening and closing the motor circuit causes a wide variation in the torque delivered by the rotor and a corresponding torque reaction on the motor frame. When the load is constant and the voltage change is small, the value of resistance across the contacts can be adjusted to reduce the torque variation to a minimum. In most cases, however, where quiet operation is essential, it is necessary to resort to the use of a heavy motor frame or, as shown in Fig. 4, to some form of resilient cushion mounting.

Radio Interference

Suppression of radio interference in governor-controlled motors is a more difficult problem than it is in regular series-wound motors, for the action of the governor contacts greatly increases the amount of disturbance. Satisfactory suppression is possible with capacitors and shielding, or with a combination of radio-frequency chokes, capacitors, and shielding.

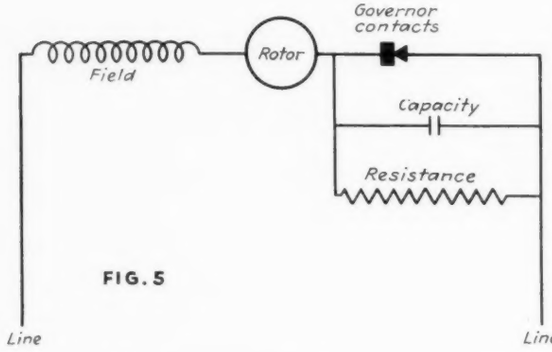


FIG. 5

Fig. 5—Circuit for governor-controlled series-wound motor, similar to Fig. 1 with capacitor added to cut down sparking at the governor contacts

Fig. 6 — Speed-torque curve for a series-wound (universal) motor, with and without governor

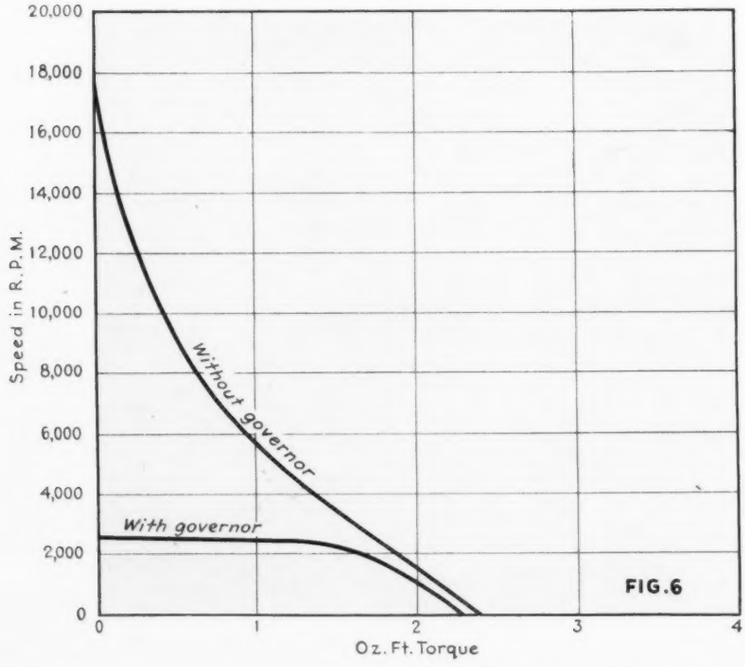
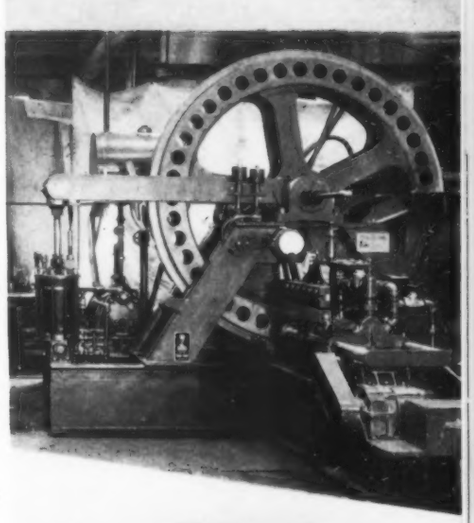


FIG. 6

HYDRAULIC OPERATION—

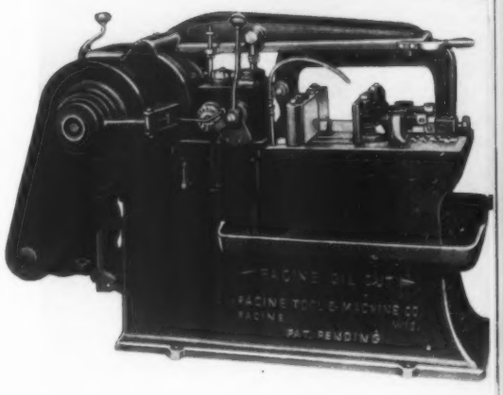
Unit Parts and Typical Circuits



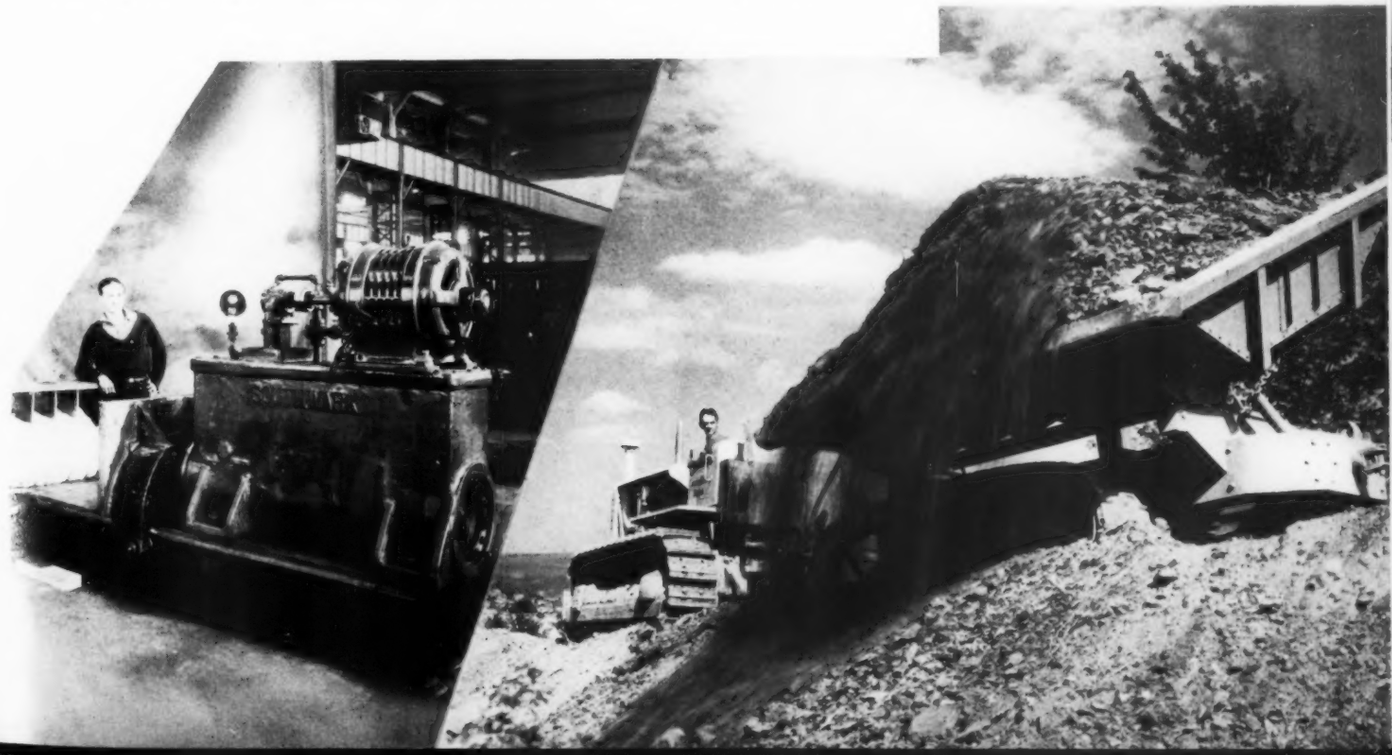
Developments in hydraulic pumps, valves, cylinders, variable-speed transmissions, control panels, flexible hose, metal tubing and other parts for hydraulic systems. Examples are given of modern hydraulically-operated machines that demonstrate the flexibility of control and simplicity of design that is obtainable. Line diagrams show the hydraulic circuits

HYDRAULIC power as applied to machinery for actuating various units has a number of features to recommend its use. Foremost among these is flexibility of control with a minimum of shifting and adjusting of controls. Whereas banks of gears were formerly required for a limited mechanical gradation of speeds and feeds, an infinite number of speeds or feeds are quickly available hydraulically by the turn of a dial. Ordinarily, quietness of operation may be expected. Also, heavy loads can be reversed without shock. While these advantages are inherent in hydraulic actuating systems in general, the manufacturers of hydraulic equipment are constantly bettering their product for easier and more efficient operation.

One manufacturer of hydraulic pumps and motors has redesigned his radial piston type of variable-speed transmission. In this new design 13 parts have been eliminated from each piston, thereby reducing the friction losses. Starting torque efficiency was raised to 88 per cent, this rating being increased to 97.6 per cent at 120 r.p.m. Although the capacity of the unit is greater, the overall dimensions have been decreased.



Remote control has been incorporated in another variable-speed trans-



mission where ordinarily the speed adjustments were made by handwheel. Speed changes are made remotely not only by mechanical means, but electrically and hydraulically as well.

Another variable-speed transmission of the mechanical type is controlled hydraulically wherein it is possible to shift the transmission from one extreme speed to the other in from 20 to 35 sec., depending on the speed ratio and size.

Oil-resisting rubber hose is available, having one or two plies of braided wire between the inner and outer layers. The hose is capable of withstanding working pressures up to 7,500 per sq.in., and bursting pressures up to 30,000 lb. per sq.in.

Seamless steel tubing having a ductility approaching that of copper and of the same outside diameters can be readily bent and formed with hand tools. Made of a special low carbon steel, the tubing is resistant to corrosion and free from oxide or scale.

A double-acting, piston-ring type of hydraulic cylinder for pressures up to 1,500 lb. per sq.in., or higher where required, is without the usual longitudinal tie-rods. The caps can be assembled independently of each other so that the inlet or outlet can be located at the top, bottom or either side.

A new electric-hydraulic panel control for attaching to a machine is used when automatic feeds and rapid traverses are required. Starting, reversing and stopping are controlled by pushbuttons or limit switches, relays and solenoids being built into the control panel.

Pressure pulsations in hydraulic circuits have been a problem wherein prompt and accurate gaging was not possible. An adjustable dampener has been developed recently which permits the operator to filter out or eliminate these pulsations before they reach the sensitive indicating mechanism of the gage.

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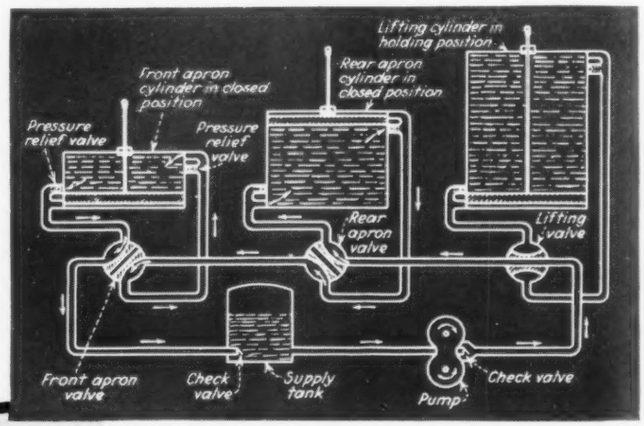
Hydraulically-Interlocked Cylinders

SEPARATE valves control the three functions of the hydraulically actuated Dig-N-Carry scraper, manufactured by The Heil Company. One valve is used for lifting and lowering the scraper; one for opening and closing the front apron; and one for controlling the rear apron. To load the scraper the front apron is opened and the cutting edge lowered. When the bowl is filled the front apron is closed and the scraper lifted. To dump the load, the front apron is opened and the rear apron travels forward pushing the earth from the bowl.

In the hydraulic diagram, the lifting cylinder piston is down in the holding position. The lifting valve is closed, thereby locking that part of the system. The oil is by-passed through the lifting valve at this time, when the scraper is digging. In the digging position the rear apron is back, and the valve being open, admits the oil to the rear of the rear apron cylinder piston, as shown. The front apron is closed when its cylinder piston is in the back position. As shown in the diagram, the oil by-passing through the lifting valve flows through the rear apron valve and cylinder, then through the front apron valve and cylinder, returning to the supply tank.

Because all of the valves can be operated at the same time, the size of the cylinders is graduated so as not to starve any one cylinder. The lifting cylinder has twice the capacity of the rear apron cylinder and four times the capacity of the front apron cylinder. By this arrangement there is no loss of efficiency. The hydraulic system is operated by a 300- to 400-lb. per sq. in. pressure.

Although the illustration shows the valve controls mounted on the scraper platform, the scraper can also be operated by remote control. In the latter instance the controls can be furnished in the tractor that draws the scraper. With remote control the scraper can be operated from the tractor and from the scraper platform simultaneously.



Solenoid Controlled Operations

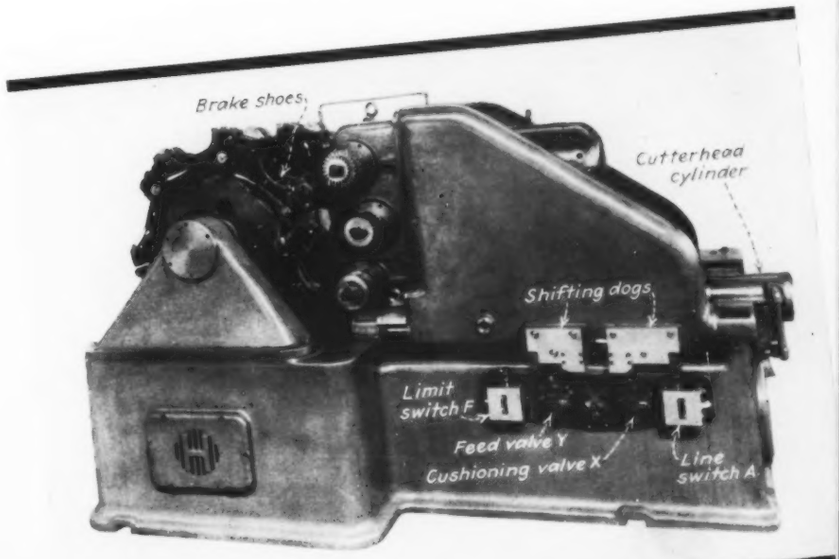
THE special 6-spindle milling machine built by The Hammond Manufacturing Company is used for machining malleable iron brake shoes. Both ends of the brake shoe are straddle-milled and the female end is also slotted. The machine has six stations, one for loading, two for roughing and finishing, and three idle. Four shoes are loaded at one time and the machine finishes 960 shoes per hour.

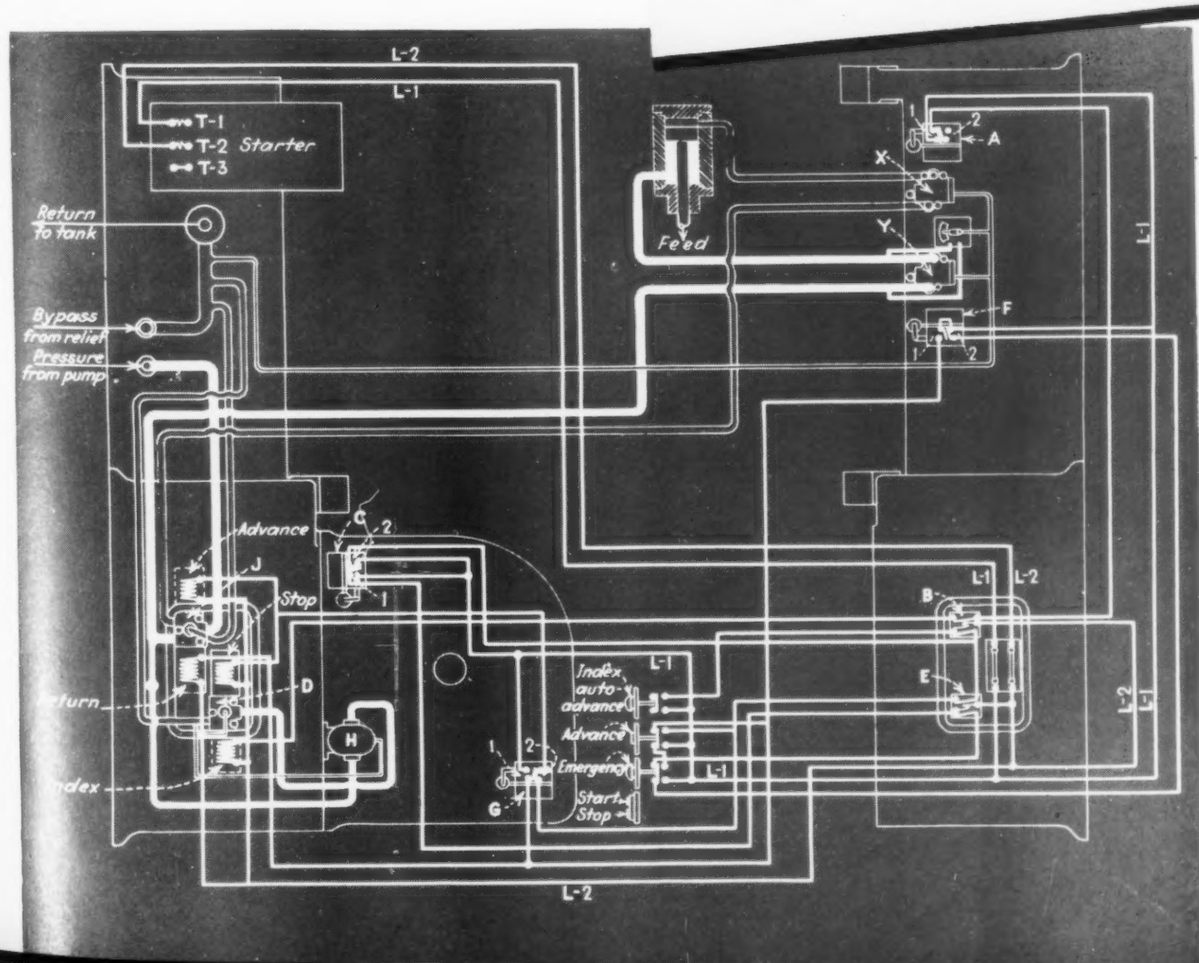
A lock pin on the front of the reciprocating cutter head locks the Geneva operated turret in the cutting position. The ways upon which the cutter head slides are round in shape. Both the ways and the cutter head bushings are hardened and ground allowing for replacement to maintain the original setting. This design was used in preference to vee or flat ways as being more accurate and easier to replace. The cutter spindles rotate on tapered roller bearings and the turret shaft is mounted on double row ball bearings.

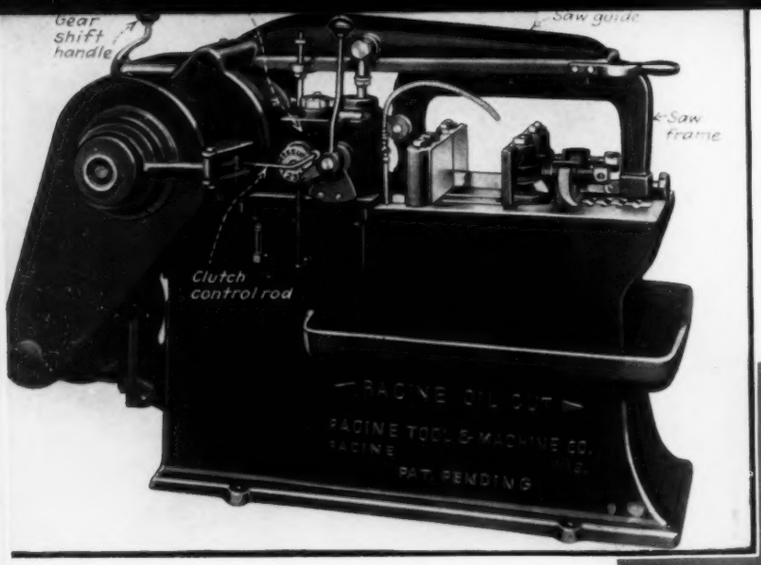
A combination electric-hydraulic system, using Vickers equipment throughout, controls the various operations. After loading, the operator touches the *Index* button at the front of the machine, closing relay *B* which is held in the closed position by contacts 2-*C*. When the head withdraws, thereby closing contacts 1-*A*, the *Index* solenoid is energized to shift the hydraulic valve *D* and opens the oil pressure to the fluid indexing motor *H* shown at the left in the diagram.

As the index is completed, contacts 2-*C* are momentarily broken, allowing relay *B* to open, and contacts 1-*C* are momentarily made to close relay *E* which is held closed through 2-*F*. As long as relay *E* remains closed, the *Advance* solenoid is energized to shift the hydraulic valve *J* and opens the oil pressure to advance the cutter head. When the cutter head reaches the forward end of its stroke, it momentarily breaks contact 2-*F* to drop relay *E* and causes 1-*F* to energize the *Return* solenoid, which in turn, shifts the hydraulic valve *J* to withdraw the cutter head.

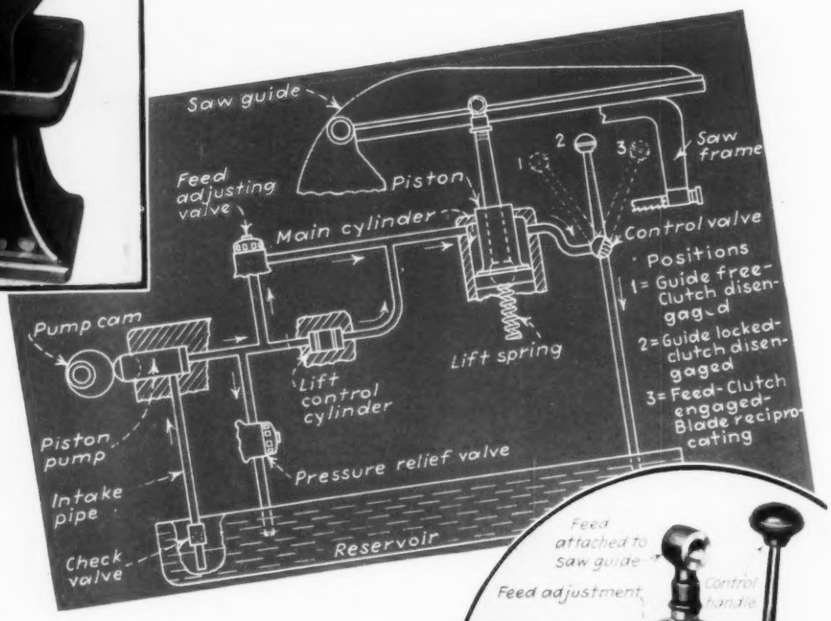
Limit switch *G* provides an interlock which automatically withdraws the cutter head if the turret, for any reason, is moved out of working position. The hydraulic valve *X* cushions the return of the cutter head. Valve *Y* is closed to terminate the rapid advance of the cutter head and to advance it into the feed rate at the proper time.





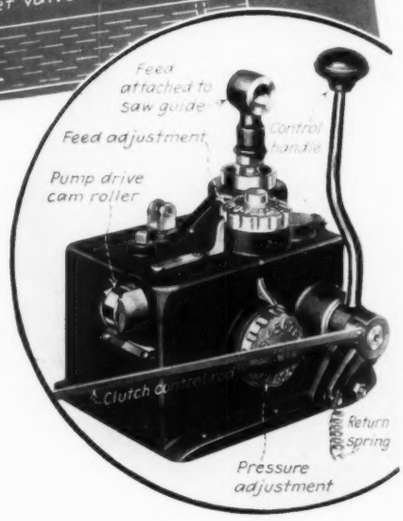


Self-Contained Unit for Feed Control



IN THE Racine Tool & Machine Company's metal saw, the complete hydraulic feed is incorporated in a single unit, as shown in the accompanying pictures and diagrams. The single-acting hydraulic pump is driven by a cam on the final drive shaft of the saw. The purpose of the lift control cylinder is to relieve the pressure in the main cylinder when the pump is on the return stroke. This permits the lift spring to raise the saw on the non-cutting stroke.

As can be seen in the picture, the control rod of the main clutch is interlocked with the operating handle so that the clutch is engaged only when the operating handle is in position three, as indicated in the diagram. The feed adjusting valve controls or limits the pressure on the cutting stroke by bypassing the oil supply if the preset pressure is exceeded.



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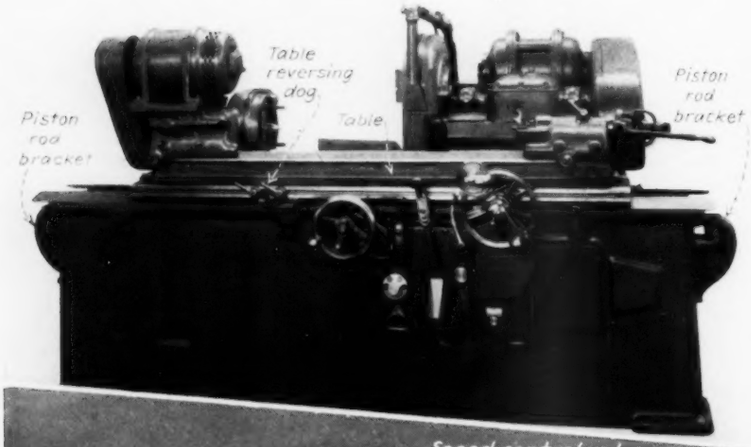
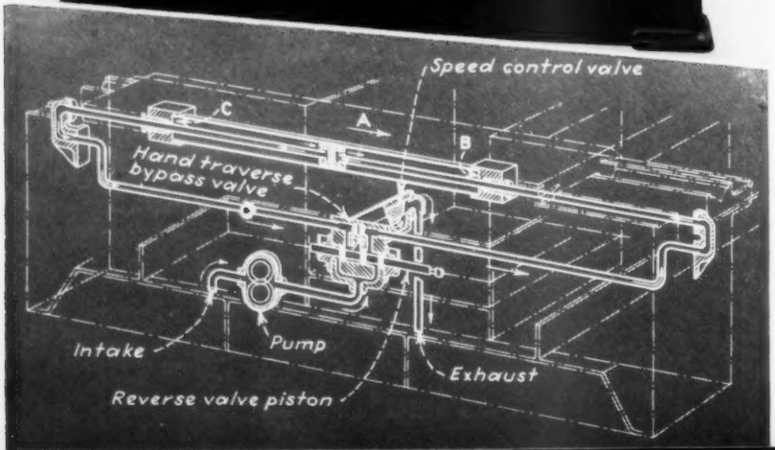
Hydraulic Table Drive





IN THE hydraulic table drive of the 10 in. Type C cylindrical grinder made by the Norton Company, the piston cylinder is fastened to the underside of the table and the two hollow piston rods are fixed in brackets, one at each end of the machine base. With this design the piston rods are always in tension, permitting a smaller rod than if the rod were under compression.

For traversing the table, oil is pumped to the reversing valve in the direction of the arrows, as shown at the right of the machine, to move the table in the direction of the arrow marked A. The oil passes through the piston head and exerts pressure against surface *B*. With the pistons sationary, and the table moving towards the right, the oil in the left portion of the cylinder is forced back through the hollow piston rod and the discharge pipe into the reservoir.

For automatically reversing table, reverse valve piston is shifted to left, causing oil in the circuit to travel opposite to di-

rection shown, exerting a pressure on the surface *C*, thereby causing the table to travel in the opposite direction of arrow *A*. A hand traverse bypass valve is provided for operating the table manually. An infinite number of table traversing speeds within a range of 7 to 360 in. per min. are obtainable.

Although the diagram shows only the table traversing portion of the hydraulic system, the machine can be arranged for hydraulic wheel head traverse and automatic feed.

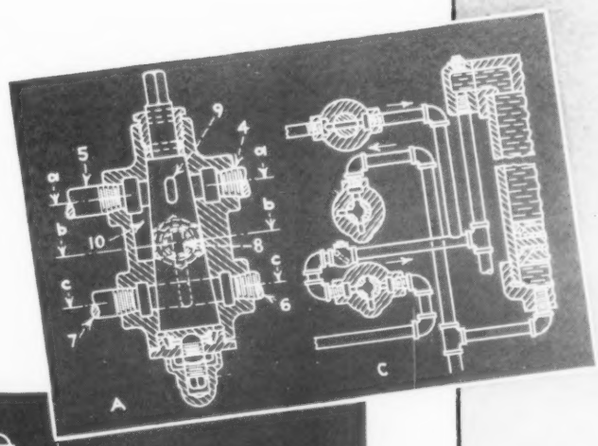
▼ ▼ ▼

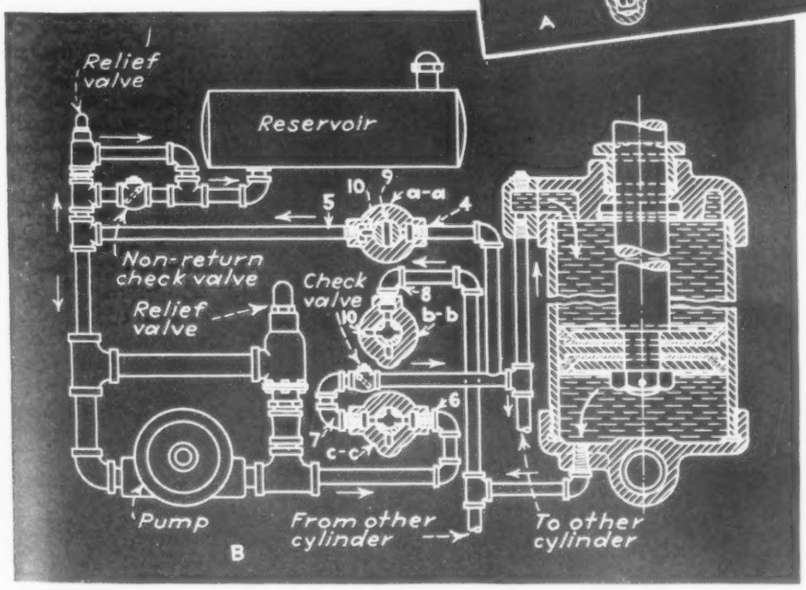
Manual Triple Valve Controls 100-Foot Ladder

THE 100 ft. aluminum ladder on the Peter Pirsch & Sons Company hydro-mechanical aerial ladder and water tower is raised by means of a 30-gal. per min. hydraulic pump, capable of transmitting pressures up to 1,000 lb. per sq. in. During ordinary operation of the ladder, only 350 lb. per sq. in. is required, the system having sufficient reserve to raise several sections of hose or a fireman to the fifth or sixth story of a building.

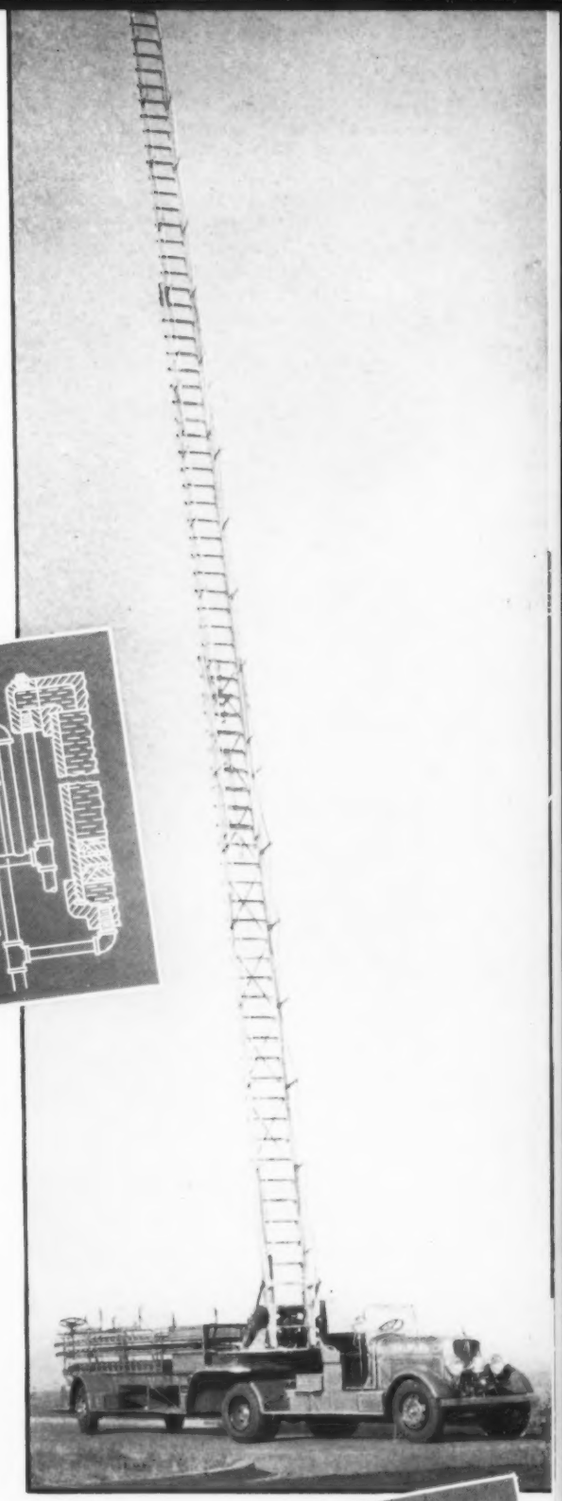
To make it impossible for the ladder to be jolted, the hydraulic circuit is designed so that a body of liquid is locked on both sides of the operating pistons. This requires a special design of valve having four positions: (1) for raising the ladder; (2) holding in position; (3) lowering by gravity; (4) lowering by force.

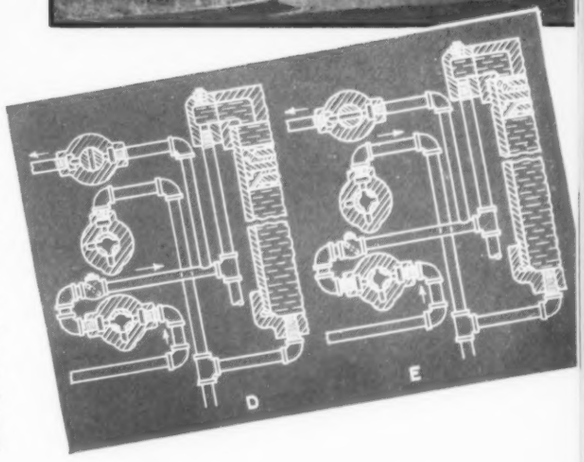
This valve is mounted in the turntable, and is connected by means of a double mechanical universal joint to a bevel gear set at the control stand with a shaft running up to the center of the control stand.





The valve is shown in vertical section at *A*. Each of the diagrams *B*, *C*, *D* and *E* show three cross-sections of the valve, *a-a*, *b-b*, and *c-c*, with the piping arrangement for each section. At *B* is indicated the position of the valve, when the ladder is to be lowered by force. At *C* is shown the valve position when lowering the ladder by gravity. At *D* is shown the valve position after the ladder has been raised and to maintain it in a raised





and locked position. At *E* is shown the position of the valve when it is desired to raise the ladder from the horizontal position on the trailer.

As an example of the operation of the hydraulic circuit, the piping diagram at B shows the ladder being lowered by force from an elevated position to a horizontal position on the trailer. The pump forces the liquid, Prestone being used in this instance, in the direction of the arrow to the lower part of the valve through inlet *6*. It passes directly through the valve to outlet *7* at the lower portion of the valve, then through the check valve to the top of both cylinders. The fluid that is displaced from the lower portion of the cylinder will pass into the center portion of the valve at *8* and up through the duct *10* to the upper part of the valve and out through outlet *5*. The fluid is then conducted back to the reservoir. A study of the other diagrams will show how the circuit controls the other operations.

In view of the fact that the fluid displaced from the bottom of the cylinders is more than sufficient to fill the top of the cylinder because of the space taken up by the piston rod, the excess of fluid will be bypassed through the relief valve and back to the reservoir.

The power for driving the hydraulic pump is taken from the gasoline motor that drives the vehicle, the speed of which may be changed by the operator by means of a foot accelerator immediately below the operating controls.

Because of the simplicity of hydraulic operation it was possible to build a longer and stronger ladder than heretofore. It is said that this is the first 100 ft. aerial ladder ever built in the United States. The ladder is made of heat treated extruded aluminum alloy having 59,000 lb. per sq. in. tensile strength.

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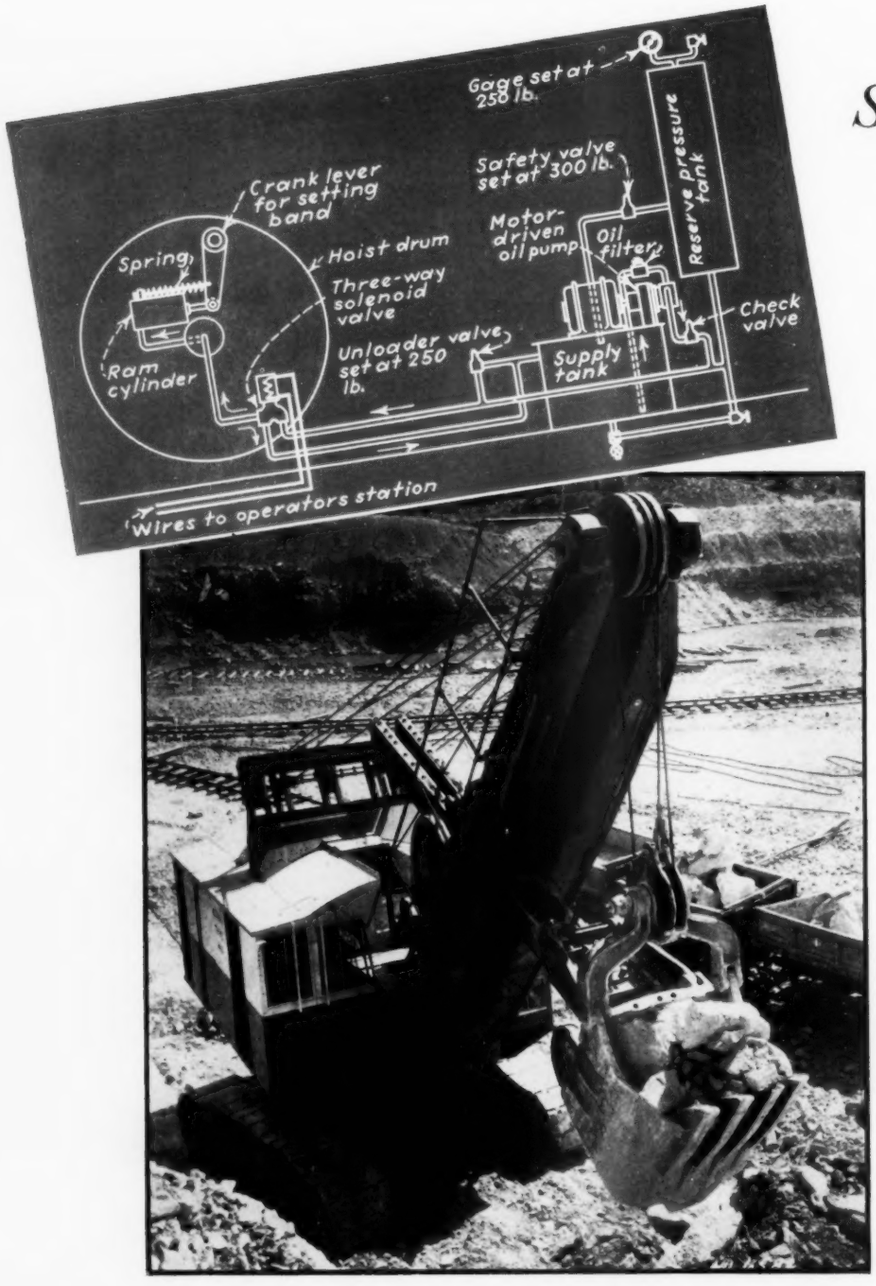


Three-Way Solenoid Valve for Clutch Control

ON THE 2½ cu. yd. quarry type shovel made by the Marion Steam Shovel Company, hydraulic control is used to release the spring-set friction band through which the hoist gear drives the hoist drum. A hydraulic pump delivers oil to a partially filled closed tank which serves as an accumulator, the pressure being developed by the compression of the air in the tank. An unloader valve set for 250 lb. per sq. in. bypasses the oil back to the supply tank when the maximum operating pressure has been reached.

For operating the clutch, a latch on the hoist controller in the operator's cab controls a 3-way solenoid operated valve. This valve opens to allow oil to be delivered to the hydraulic operating cylinder to release the band or opens to allow the oil to be discharged from the cylinder so that the springs can apply the band pressure.

A 3-way solenoid operated valve is supplied for each drum when the machine has a number of hoisting drums. When a number of valves are used, a check valve is placed between the main pressure line and each valve. This prevents a sudden pressure drop when a valve is opened to a hydraulic operating cylinder.

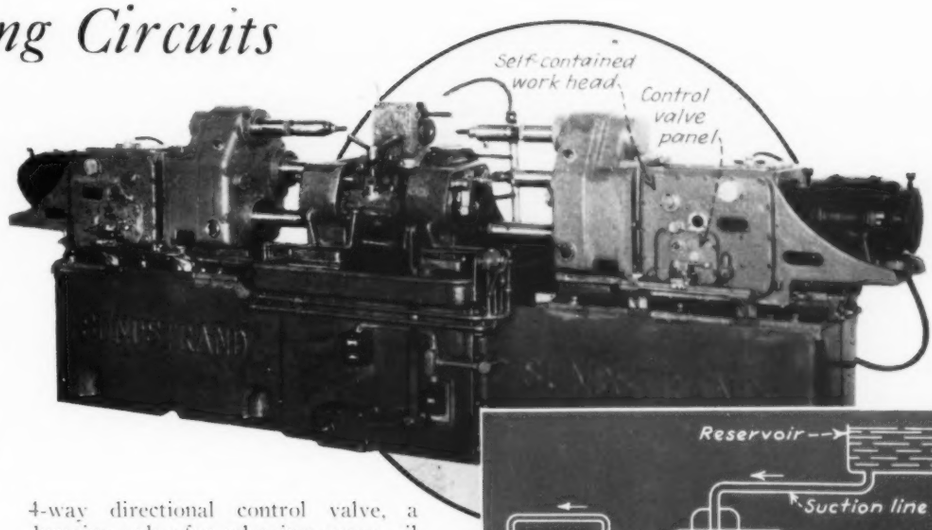
Although not shown in the illustration, the propelling lock brake provides positive locking and is operated in a similar manner as described above. The brake is spring-set and hydraulically released, being electrically controlled from the operator's station. The lock is located on the horizontal propelling shaft under the lower frame of the machine.

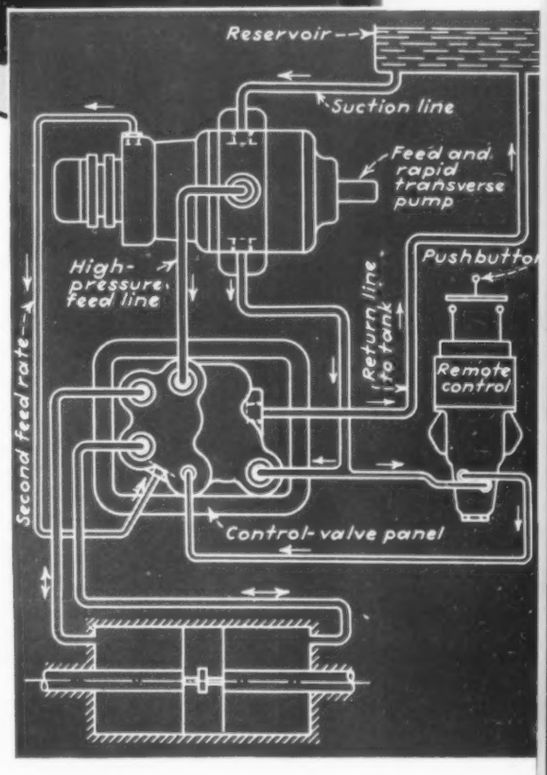
Self-Locking Circuits

IN THE unit type of machine as illustrated, wherein standard units serve as basic elements in the design of single purpose machines, one or several self-contained work heads incorporating the spindle drive and feed mechanism are used. This form of construction is readily adapted to milling, drilling, boring, reaming and chamfering machines. A self-locking hydraulic circuit for such operations, designed by the Sundstrand Machine Tool Company is shown here.

The circuit diagram shows a system for rapid traverse, fast feed, slow feed, dwell against a positive stop, quick return and stop. One pump of the combination variable and constant displacement type pumping unit gives one feed rate and rapid traverse; the other pump giving a second feed rate. Any number of heads or units, each with its individual pump and panel, can be operated by one push button station.

The control valve panel includes a 4-way directional control valve, a dumping valve for releasing excess oil under no pressure to the sump, a pressure control valve that automatically causes the circuit to lock, thus preventing any tendency of the head to jump forward when cutting resistance diminishes or ceases, and a control stem.





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Variable Hydraulic Feeds

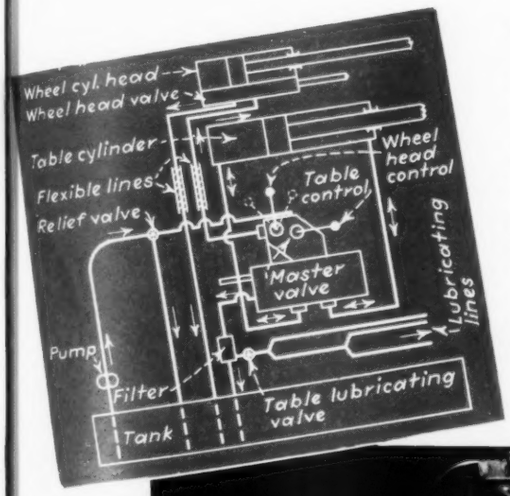
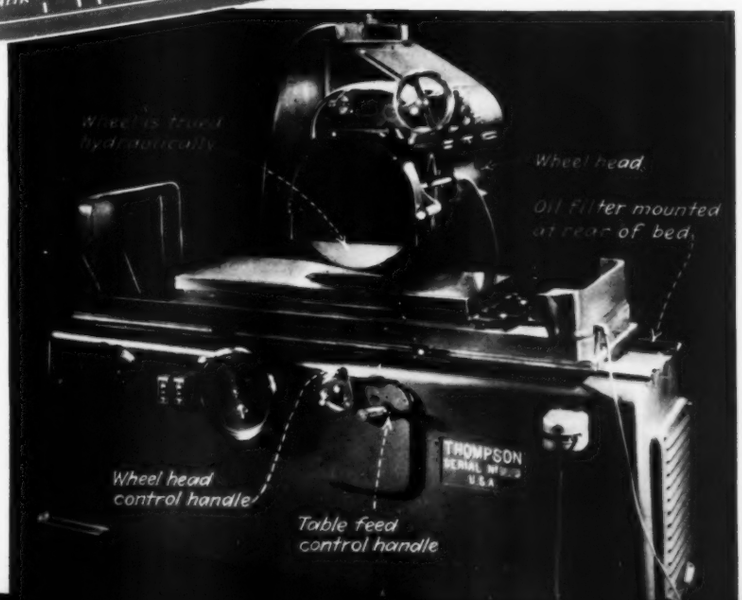


TABLE traverse, wheelhead cross feed, and wheel truing are controlled hydraulically on the surface grinding machine manufactured by the Thompson Grinder Company. Because vibration is detrimental especially to grinding machines, the hydraulic power unit, consisting of the motor and pump, is insulated from the machine base by vibration absorbing rubber blocks. These rubber blocks are dipped in lacquer to make them impervious to oil. The connection between the hydraulic oil pump and control valve is made of rigid tubing mounted in such a manner to permit free oscillation of the power unit, without transmitting the vibration to the control valve.



Automatic hydraulic feed at each table reversal moves the wheelhead from .002 in. to .005 in. per stroke, according to the adjustment. The table travel is adjustable for speeds up to 100 ft. per min. Hydraulic rapid traverse is controlled by the same lever as used for cross feed, the wheelhead traveling at the rate of 20 ft. per min. when so engaged. For wheel truing a slow continuous feed is used while the wheel face passes over a truing tool. Manual feed of the wheelhead is accomplished by a worm and worm wheel device operating through a splined clutch and locking out the hydraulic movement when used.

On some of the larger machines not equipped with electric elevating mechanism, a hydraulic counterbalance, consisting of a small valve and

cylinder, is actuated when elevating the wheel slide. With the use of this counterbalance, the operator need only to spin a handwheel to position the wheelhead unit where desired.

The hydraulic oil supply tank is inside the base casting. The oil at 150 lb. per sq. in. pressure is pumped to the master valve as shown in the diagram, from whence it is distributed to the table and wheelhead cylinders. A valve in the hydraulic system regulates pressure lubrication to the work table. The hydraulic circuit includes a semi-automatic filter of the continuous cleaning type.

▼ ▼ ▼

Regenerative Hydraulic Circuit Used in Shaper-Planer

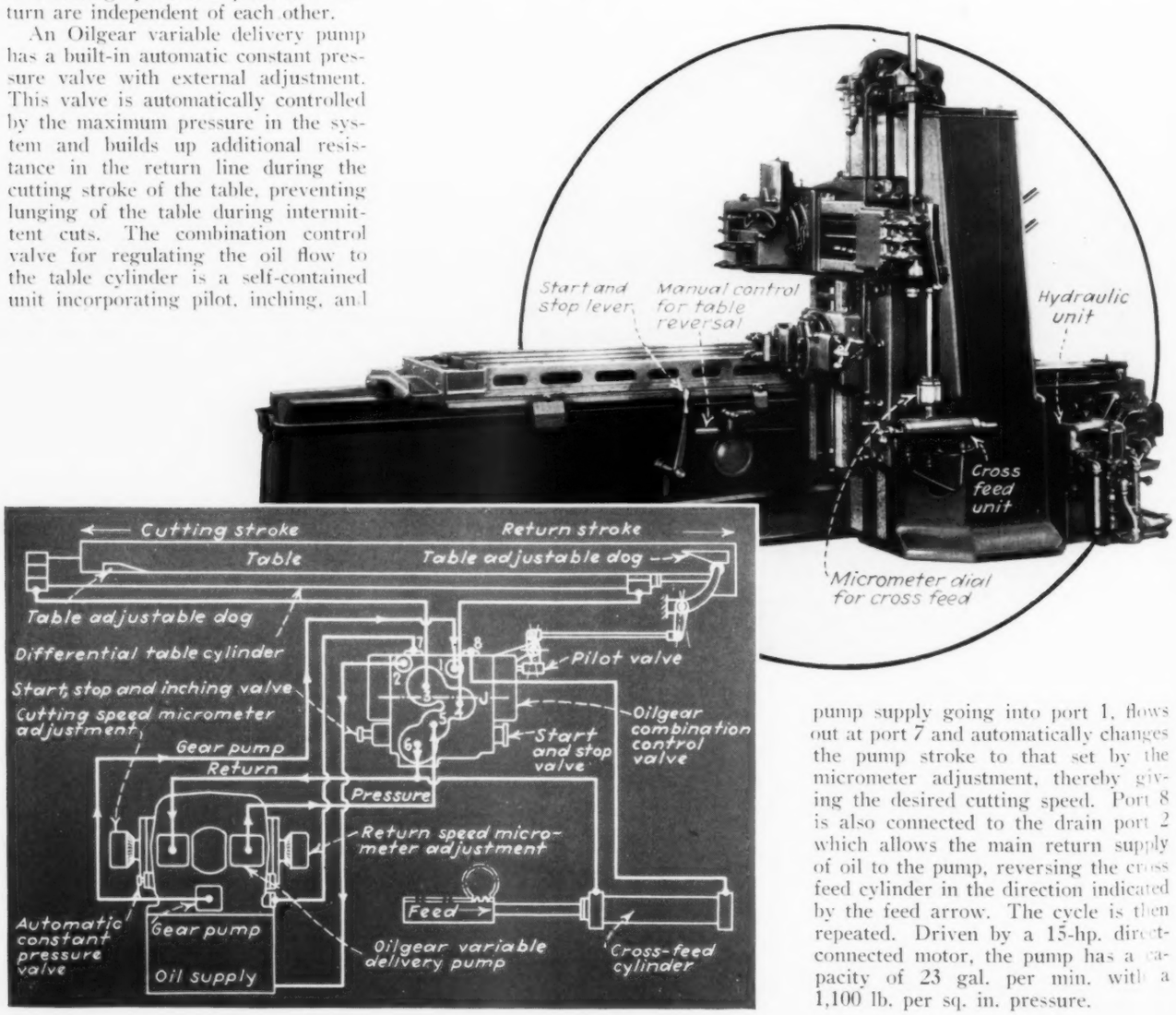
BOTH table and cross feed of the Hydraulic Shaper-Planer, built by the Rockford Machine Tool Company are operated hydraulically by a regenerative type of circuit, whereby constant speed and pressure are maintained throughout the entire cutting stroke. The power is applied in a straight line close to the table ways. The cutting speed and quick table return are independent of each other.

An Oilgear variable delivery pump has a built-in automatic constant pressure valve with external adjustment. This valve is automatically controlled by the maximum pressure in the system and builds up additional resistance in the return line during the cutting stroke of the table, preventing lunging of the table during intermittent cuts. The combination control valve for regulating the oil flow to the table cylinder is a self-contained unit incorporating pilot, inching, and reversing valves. Adjustable table dogs operate the pilot valve which in turn moves a reversing plunger at *J* for table reversal.

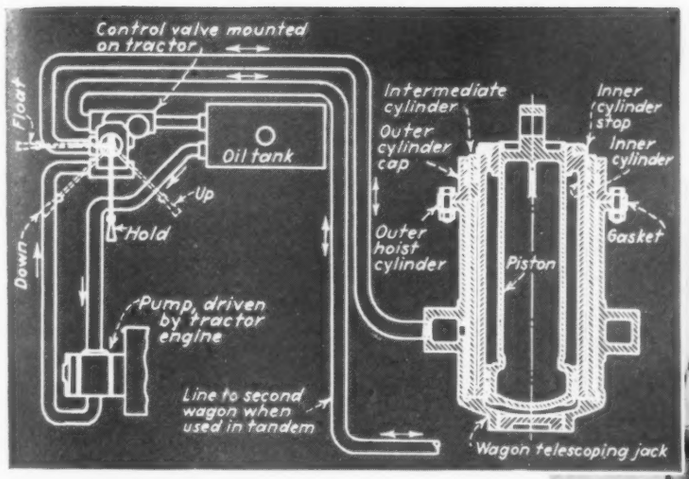
The head cross feed acts in harmony with the table cylinder from the same high pressure circuit. The cross head cylinder operates an over-running clutch which rotates a vertical shaft in one direction. The amount of feed per table stroke is determined by the length of the piston travel, which is controlled by a micrometer adjustment.

Starting is accomplished mechanically by movement of the starting valve, the pilot valve being so positioned that the gear pump supplies oil to port 1. The reversing plunger at *J* is moved to the left, the supply of oil from the gear pump flowing out of port 8 and into the right-hand end of the table cylinder, moving the table towards the left. The main pressure volume of the pump flows in at port 5 and out of port 3 to the left-hand end of the table cylinder, thereby returning the table to the starting position. When the adjustable dog at the left strikes the roller on the control mechanism, the pilot valve is reversed to the left, allowing the oil from the gear pump to move the main reversing plunger at *J* and causing the main pressure volume to flow through port 5 and out at port 4 into the right-hand end of the table cylinder. The table then moves to the left for the cutting stroke.

At the instant of reversal, the gear pump supply going into port 1, flows out at port 7 and automatically changes the pump stroke to that set by the micrometer adjustment, thereby giving the desired cutting speed. Port 8 is also connected to the drain port 2 which allows the main return supply of oil to the pump, reversing the cross feed cylinder in the direction indicated by the feed arrow. The cycle is then repeated. Driven by a 15-hp. direct-connected motor, the pump has a capacity of 23 gal. per min. with a 1,100 lb. per sq. in. pressure.



Telescoping Hydraulic Jack



THE La Plant-Choate 2-way dump wagon is operated by a 3-stage hydraulically operated telescoping jack. This jack is carried in a hammock or swing mounted in the center of the wagon frame. The dump body pivots, two located on each side of the frame, are so arranged that by manual operation, the pivot shaft on the side to which the load is to be dumped, is located in place. At the same time the opposite pivot shaft is released so that the shaft can swing away from its bearings. The oil pressure is transmitted to the jack through a flexible hose.

As shown in the hydraulic diagram, the pump, driven by the tractor engine, draws the oil from the tank and delivers it to the control valve which is also mounted on the tractor. The valve has four positions: raising, lowering, holding, and floating the dump body.

The telescoping jack is constructed of Meehanite iron and steel castings. The U-leather packings have hemp expanders inserted between the lips. Solid duck packings are also used for each of the three stages, these being inserted into grooves ahead of the U-packings and serve as wipers to exclude dust and grit.

The bore of the largest cylinder is $10\frac{1}{2}$ in., and that of the smallest cylinder is $7\frac{3}{4}$ in., the intermediate cylinder being $8\frac{7}{8}$ in. diameter. The diagram shows the jack collapsed while in the photograph the jack is extended to its full stroke of 46 in., each stage having approximately $15\frac{3}{8}$ in. travel. In summer oils of S.A.E. 30 or 40 viscosity are used and S.A.E. 10 for winter service. The normal working pressure in the hydraulic system is between 300 and 500 lb. per sq.in. and the pump is capable of operating in excess of 1,000 lb. per sq.in. pressure. Black steel pipe and extra heavy fittings are used, flexible hoses being inserted in all lines of any length to prevent distortion or vibration failures.

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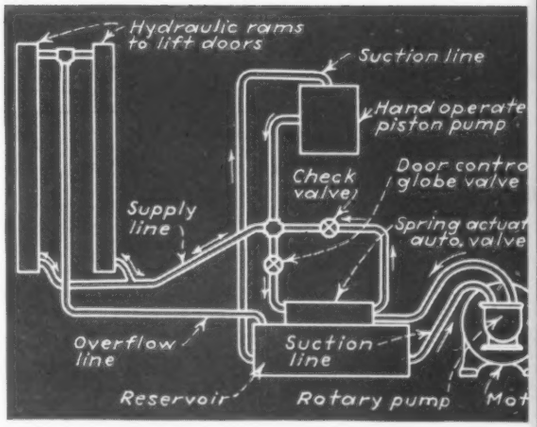
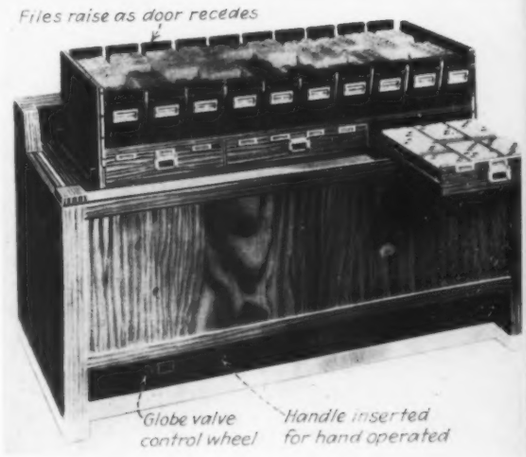
Hydraulics for Office Equipment



THE use of hydraulics is not confined to machinery, as evidenced by its application to the electric-hydraulic Recordesk safe made by the Diebold Safe & Lock Company. The top cover or door of this record-holding desk is opened and closed by the action of two hydraulic rams. After the combination is dialed and the door unlocked, a button is pushed to start an electric motor connected to the pump. Refrigerator oil at 350 lb. per sq.in. pressure is forced through a check valve to the lower ends of the two hydraulic rams connected to an auxiliary rear wall into which the door recesses.

As the auxiliary wall raises to the extreme upper position, the door folds back into the recess. The motor is then automatically shut off and the door and rear wall drop by gravity, disappearing into the body of the safe. The weight of the door forces the oil back through the supply line and into the reservoir. As the door recedes, the card trays are automatically raised to the position shown in the photograph. The reverse takes place when the desk is closed.



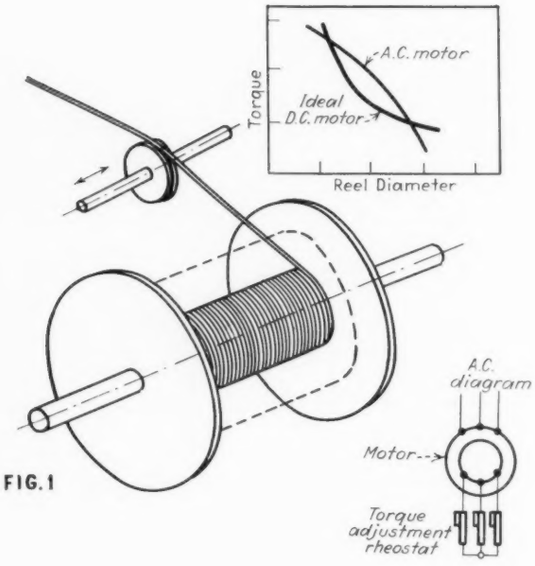


FIG. 1

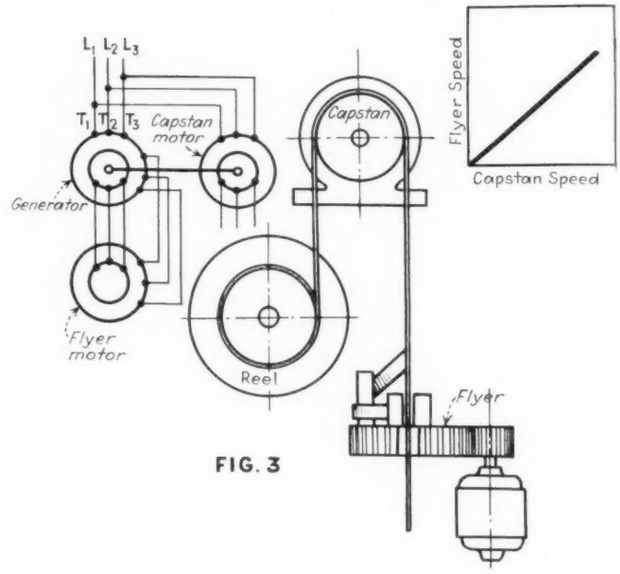
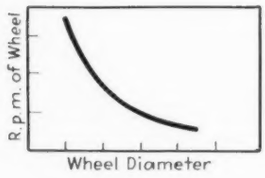


FIG. 3



Methods of Electric Control—I

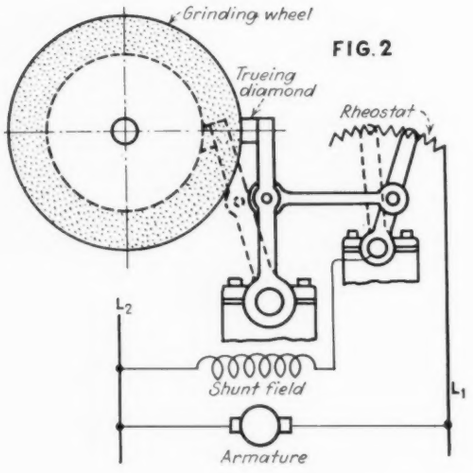


FIG. 2

R. S. ELBERTY, JR.
Machinery Electrification Division
Westinghouse Electric & Manufacturing Company

How electrical controls can be applied to machinery for regulating peripheral speeds, rates of feed, controlling speed ratios, maintaining constant loads and for machine reversal

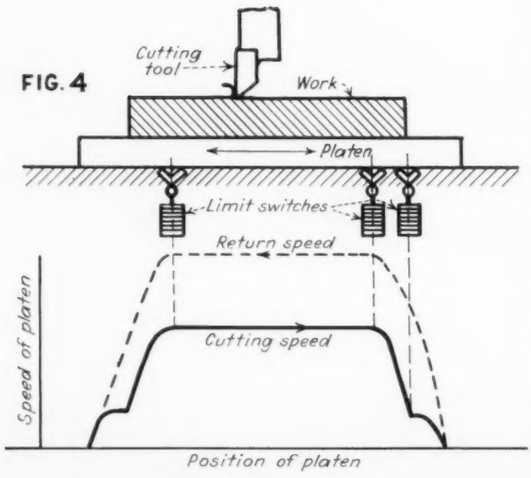


FIG. 4

Fig. 1—Constant tension with constant peripheral speed is required in this wire reel application. The application can be used on wire drawing machines, insulating machines or any other reeling operation. As the reeling diameter increases, the reel speed decreases, and at the same time the reeling torque is increased. The required constant hp. characteristic is obtained accurately with a d.c. motor and regulator type of control on shunt field. An a.c. wound rotor motor with secondary resistance control approximates ideal conditions

Fig. 2—For automatically limiting the peripheral speed of a grinding wheel, the truing diamond is mechanically interlocked with the wheel motor field rheostat. The wheel r.p.m. is increased as the wheel diameter decreases.

Fig. 3—A wire insulating machine requires a constant speed ratio between capstan motor and flyer for starting and running. The capstan motor drives a frequency changer or transmitter electrically connected to the synchronous motor of the flyer. The speed ratio between flyer and capstan is constant at all times.

Fig. 4—For high-speed cutting on a metal planer, the tool enters the work at a slow speed to prevent tool breakage, cutting speed is then increased and near the end of the cut the cutting speed is reduced to prevent breaking out of edge of work. This speed control is accomplished by limit switches which put full field on the motor before the tool leaves work. After the return stroke re-

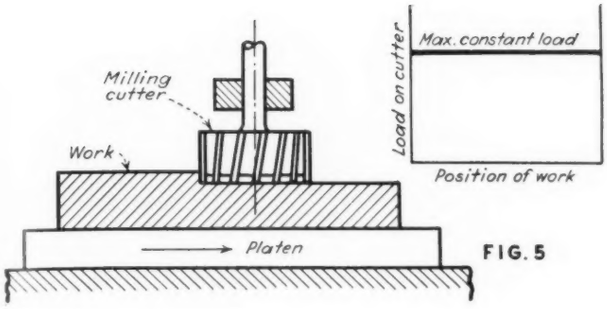


FIG. 5

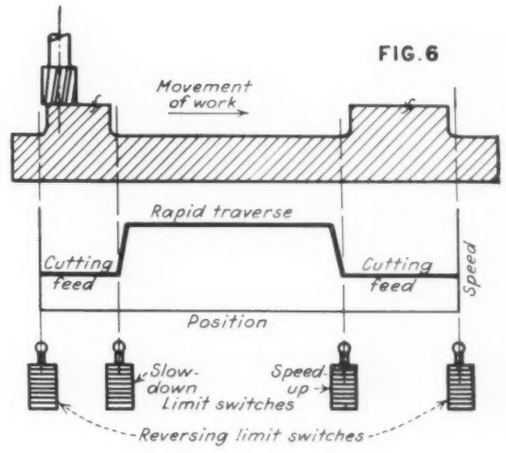


FIG. 6

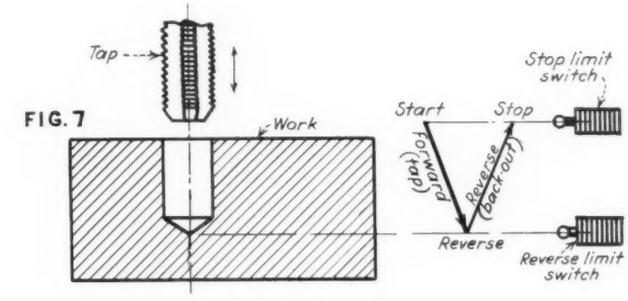


FIG. 7

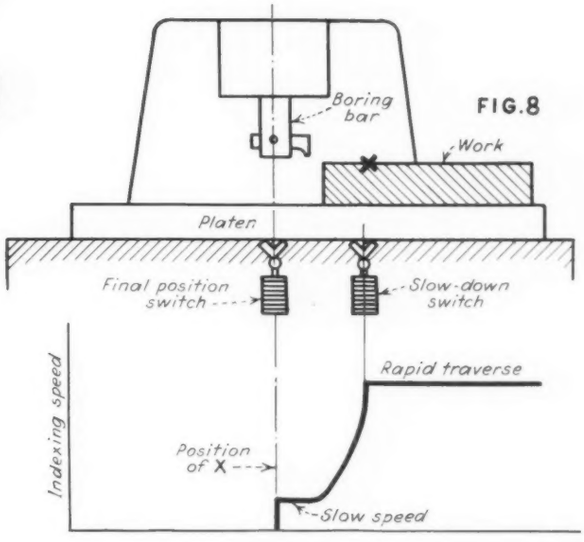


FIG. 8

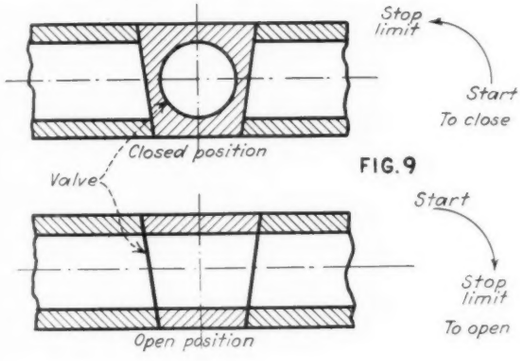


FIG. 9

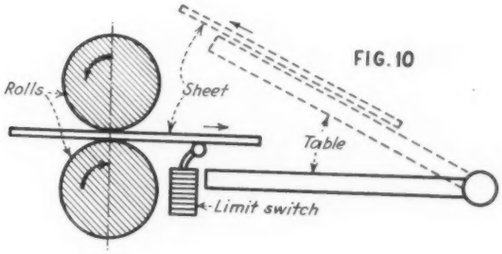


FIG. 10

layed acceleration keeps full field on motor until tool enters work, upon which fast cutting speed is resumed.

Fig. 5—To keep load constant on the cutter and spindle of a milling machine for maximum production, a relay controlled by the armature circuit of the d.c. spindle motor regulates the field of d.c. feed motor. This automatically controls the feed within limits to maintain a maximum constant load on the spindle motor.

Fig. 6—When milling work having a gap between machined surfaces, production is increased by rapid traverse between machining positions. Jump feed control is accomplished by means of adjustable limit switches, multi-speed motors, and suitable magnetic controls.

Fig. 7—Accurate positioning of reversing and stop limits is necessary on tapping machines, especially when tapping blind holes. Special a.c. reversing motors for tapping service permit as many as 60 reversals per min. The use of two or four-speed motors reduces the number of gear changes required. Accurate limit switches, quick-acting contactors, and high torque motors are used. A plug stop is used for braking at the "out" position.

Fig. 8—Accurate location of boring tool for indexing requires extremely slow speed of work table to prevent over-travel when stop limit is reached. A d.c. motor and control is used; heavy armature series resistance and armature parallel resistance provide for creep speeds for final positioning.

Fig. 9—For accurately stopping a slowly moving body, such as a rotary type valve, a geared switch is mounted on the motor, operating at motor speed. The motor can be stopped within one-fourth revolution and with a gear reduction of 100 to 1 between the motor and valve, the valve can be accurately located to within less than 1 degree.

Fig. 10—On a sheet catcher, the table must reverse and return the sheet as soon as it passes through the rolls. Since the length of the sheet varies, the sheet itself is used to operate the limit switch which reverses the table. This application requires specially designed motors and exceptional ruggedness in the control equipment.

NEWS

New Ford Laboratory Placed in Operation

ANOTHER unit of the Ford Company's $37,000,000 expansion and modernization program was completed when the new chemical and metallurgical testing and production control laboratory was placed in service by the Ford Motor Company at the Rouge plant at Dearborn, Mich. Completely air-conditioned and equipped with the latest testing and inspecting apparatus, this laboratory is one of the most modern in the United States. It is now working on a 24-hour day basis, with a staff of 65 technicians.

Included in the equipment is a new X-ray machine having an oil-cooled fine focus radiographic tube of 230,000 volt capacity. It has sufficient intensity to penetrate 4 in. of steel and is capable of detecting flaws less than 2 per cent of the total thickness of the specimen. It is housed in a lead-walled room and the operator watches the machine from outside the room through a safety lead glass.

For use in research to improve casting and steel treating technique through a study of the atomic structure of the finished steels and alloys, the X-ray department is equipped with a diffraction machine. This machine is capable of taking pictures in 20 min. which formerly required from 24 to 70 hr. exposure.

Another new instrument in the laboratories is the profilograph, designed at the University of Michigan. This instrument is the third of its kind to be constructed. Through a magnifying system, the profile is magnified 2,000 times vertically and 64 times horizontally. Thus the profile graph of a surface of a $\frac{1}{8}$ in. specimen of steel becomes a chart 8 in. long with minute irregularities showing as deep ridges.

Huge Oil Supply for Queen Mary Turbines

ONE expects staggering figures when quoting statistics about the *Queen Mary*. Whereas, in many ordinary installations lubrication is measured in drops per min., the four turbines of the *Queen Mary*, developing 200,000 hp., have a total of 345,000 gal. per hr. of lubricating oil circulated through them. Before going into the turbine, the oil is filtered, three Auto-Klean filters serving each of the four turbines.

The same type of filters are also used for cleaning the fuel oil before it is delivered to the burner. Also, the diesel engine on each of the 24 lifeboats is equipped with a filter. They are of the cleanable type. Turning a handle on the outside of the cleaner scrapes all of the foreign matter off the cartridge. The wire winding on the cartridge leaves slits 0.008 in. wide through which the oil flows. The filters are practically the same as those manufactured in this country by Cuno Engineering Corporation which is United States licensee under the same patents.

Educators Vote for Standard Degrees

MUCH confusion has arisen from the practices of the various engineering schools in conferring different degrees for the same course. This lack of uniformity has been the subject of discussion on many occasions among educators in the field of engineering and members of engineering societies. The Society for the Promotion of Engineering Education has had three different committees and reports on the subject, while the Engineers' Council for Professional Development has recognized the problem in the deliberations of its Committee on Professional Recognition.

At its Ithaca Meeting in 1935, the Committee on Degrees in Engineering of the S.P.E.E. contained in its report provisions for unifying the names of, and requirements for, engineering degrees, including honorary degrees.

Using civil engineering as an example, the S.P.E.E. Committee recommended the degree of Bachelor of Civil Engineering (B.C.E.); Master of Civil Engineering (M.C.E.); Doctor of Civil Engineering (D.C.E.); Master of Engineering (M.Eng.); Doctor of Engineering (D. Eng.), and Civil Engineer. The first three are the Bachelor's degree, Master's degree and Doctor's degree respectively; the last is a professional degree and the other two are honorary. The E.C.P.D. has proposed that the professional degree might be granted only to experienced engineers.

This recommendation was submitted to 160 institutions and 50 voters outside of the faculties. More than 80 per cent voted in favor of the simplified degree. But, whereas the S.P.E.E. recommended the abandonment of the professional degree, E.C.P.D. proposed that it be granted only to experienced engineers who had otherwise met the requirements for certification into the profession.

Six Technical Societies to Participate in National Metals Congress

SIX great technical societies will cooperate to stage the 1936 Annual National Metal Congress and Exposition to be held in Cleveland's Public Auditorium, October 19 to 23 inclusive. It is expected that this year's exposition will be even greater than last year's when 35,000 engineers, metallurgists and industrial men visited the show put on by 200 exhibitors.

The societies that are cooperating to stage this annual event are the American Welding Society, the Wire Association, the Institute of Metals, the American Society for Metals, the Machine Shop Practice Division of the American Society of Mechanical Engineers, and the Iron and Steel Division of the American Institute of Mining and Metallurgical Engineers. The total membership of these societies is more than 30,000 and it is expected that the Congress and Exposition will attract a large proportion of this membership.

The exposition will be held in Cleveland's Public Auditorium, as announced by W. H. Eisenman, managing director of the exposition, and national secretary of the American Society for Metals which annually sponsors this event.

In addition to the exposition there will be numerous meetings of technical sessions. One of the features will be a symposium on welding, sponsored jointly by the American Welding Society and the Machine Shop Practice Division of the American Society of Mechanical Engineers. This symposium will cover welding processes, stress analysis in welded

structures, the design of welded machine frames, the welding of non-ferrous metals and the welding of alloy steels. Details of these programs will be announced shortly.

Sound Level Meters Now Standardized

THROUGH the work of a committee of the American Standards Association, directed by the Acoustical Society of America, there has now been established a standard for the measurement of sound. The standard loudness "reference level" provides a basic unit as a starting point from which all sound can be measured. Standardization of sound meters make it now possible to obtain the same results for the same sound when measured by any standard meter.

The new standards for sound meters and sound measurements were prepared by a sub-committee of a general sectional committee under the chairmanship of V. O. Knudsen of the Acoustical Society of America as chairman and J. W. McNair of the American Standards Association, secretary. Membership of the subcommittee under the chairmanship of Harvey Fletcher of the Bell Telephone Laboratories includes representatives from 8 different industrial organizations, the National Bureau of Standards, University of Michigan and the Acoustical Society of America.

In the April number of *Industrial Standardization*, the publication of the American Standards Association, is given a series of three articles that tell about the work of this committee on sound measurements and describe the two new standards on sound measurements and sound level meters.

Different Colors by Tempering

THE well-known temper colors formed by heating steel to a temperature of several hundred degrees, have always been of interest. Often coloring for ornamentation is the chief purpose of the tempering treatment but it also gives some protection against corrosion.

Prevalent opinion is that the temper colors depend only on temperature, the colors ranging from light straw to blue which requires the highest temperature. However, experiments of the Bureau of Standards indicate that the color obtained is influenced greatly by the length of time the material is maintained at a given temperature. Also, for a given color the time and temperature required will vary with the composition of the steel. This question of the relationship between time and temperature in the coloring of steel is now being investigated by the bureau.

Temper colors are caused by light interferences by an oxide film of varying thickness. The yellow color results from the extinction of light of relatively short wave length by a thin oxide film, while the blue is caused by the extinction of light of longer wave length, a thicker oxide film being required.

MEETINGS

American Society of Mechanical Engineers — Semi-annual meeting, Dallas, Texas, June 17-20. C. E. Davies, secretary, 29 West 39th St., New York, N. Y.

Society for the Promotion of Engineering Education — Forty-fourth annual meeting, Madison, Wis., June 23-26. F. T. Bishop, secretary, University of Pittsburgh, Pittsburgh, Pa.

American Society for Testing Materials—Annual meeting, Atlantic City, N. J., June 29-July 3 R. E. Hess, assistant secretary, 260 So. Broad St., Philadelphia, Pa.

EXHIBITIONS

Great Lakes Exposition — Cleveland, Ohio, June 29-October 4. Lincoln G. Dickey, manager, Terminal Tower, Cleveland, Ohio.

National Electrical and Radio Exposition—Madison Square Garden, Sept. 18-28. Joseph Bernhard, managing director, Grand Central Palace, New York, N. Y.

National Metal Congress & Exposition — 1936 Annual meeting, Cleveland, Ohio, Oct. 19-23. W. H. Eisenman, secretary, 7016 Euclid Ave., Cleveland, Ohio. The following national societies will participate: American Welding Society, the Wire Association, the Institute of Metals, the American Society for Metals, the American Institute of Mining & Metallurgical Engineers.

A.S.T.M. Meeting at Atlantic City

THE 39th annual meeting of the American Society for Testing Materials at the Chalfonte-Haddon Hall, Atlantic City, June 29-July 3, promises to be the biggest ever held. A total of 106 reports and papers will be presented, covering practically all types of production materials.

In addition to the committee reports on metals there will be a report of the joint research committee of the A.S.M.E., and the A.S.T.M. on the effect of temperature on properties of metals, and also the report of the research committee on the fatigue of metals. Papers on metals include such subjects as damage and overstress in fatigue of ferrous metals, influence of time at 1,000 deg. F. on the characteristics of carbon steel, design of a creep test machine, forming properties of some non-ferrous metals, ductility testing of aluminum and aluminum alloy sheets, stress-relief annealing and high-strength monel metal plates.

Other committee reports will cover rubber products, textile materials, preservative coatings, and other structural materials. There will also be papers on the testing of organic finishes, methods of measuring and determining gloss, compressibility tests for molded sheet materials, the testing of rubber insulated wires and cables, and numerous other papers.

Do You Know That—

• One manufacturer is testing electrolytically deposited copper screens placed between the vacuum tank and the carburetor. The screens are circular disks with a selvage, smooth, 95 mesh on a 60 deg. angle to give maximum open area. The holes are 0.0035 in. in diameter and the screen is 0.0025 in. thick. (15)

• In porcelain enameling, the minimum radius to which the iron should be bent is 9/64 in., measured to the outside surface. Sharper bends require special attention in processing and the edge will chip if the bend is too sharp. (16)

• It takes much more pressure for gasoline to pass through a nickel screen than a copper screen, when the screen openings are of the order of 0.003 in. The explanation is that the adhesion between gasoline and nickel is much greater than that between gasoline and copper. (17)

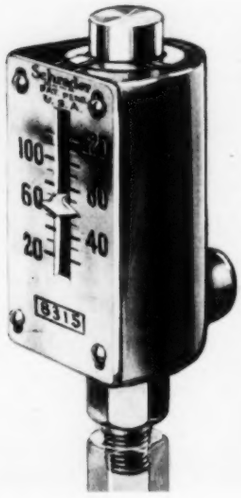
• By means of a chemical dipping process a lustrous black finish that will not chip, scale, peel or discolor can be put on all grades of common iron or steel. An immersion of five minutes in a bath at 270 deg. F. does the trick. (18)

(For details, write the editor, giving the item number.)

New Materials and Parts

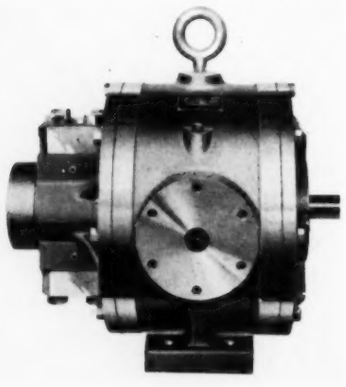
Oil Pressure Gage

Direct operating gage for use with oil hydraulic installations. It has a stainless steel piston without packing, the seepage past the piston is returned to the oil supply through a $\frac{1}{8}$ in. pipe. The pressure connection is $\frac{1}{4}$ in. male pipe thread. The gages are made regularly in five pressure ranges, lb. per sq. in., as follows:—5 to 50, 20 to 120, 50 to 350, 200 to 1,200, and 300 to 1,800. A. Schrader's Sons, 470 Vanderbilt Ave., Brooklyn, N. Y.



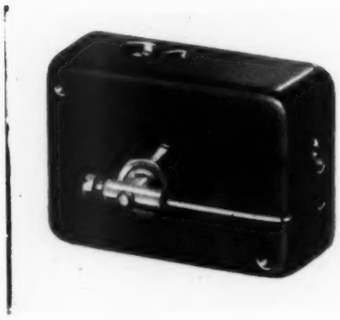
New Radial Pump

For use in operating rapid acting hydraulic presses and machinery. Delivery is variable and reversible. Direction of the flow of oil is governed by the direction in which the eccentric rotor is shifted off center, and the volume by the amount of eccentricity. Made in a range of sizes from 1 to 95 gal. per min. and for a maximum operating pressure of 2,500 lb. per sq.in. The manufacturer also announces a complimentary line of controls and valves for use with the new pumps. A line of gear pumps is also manufactured in sizes ranging from 5 to 33 gal. per min., and operating pressures up to 1,000 lb. per sq.in. The Hydraulic Press Mfg. Co., Mount Gilead, Ohio.



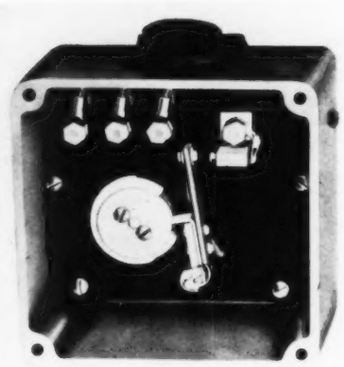
New Pilot Switch

Quick acting for sensitive control of electrical circuits. For use with counters, recorders, signal devices, lighting and alarm systems. Can be arranged to operate right or left-hand, on open or closed circuit, with reciprocating or rotary motion, and with any position of lever arm. A pressure of $\frac{1}{2}$ ounce on the arm will operate the switch. The Type ES-9 pilot switch is housed in a bakelite case, measures $1\frac{5}{8}$ x $1\frac{1}{8}$ x $\frac{5}{8}$ in. and weighs an ounce. The operating arm is 1 in. long. It is rated at $\frac{1}{2}$ amp. a.c., $\frac{1}{4}$ amp. d.c. on inductive, resistance, or lamp loads. The Production Instrument Co., 1325 S. Wabash Ave., Chicago, Ill.



Motor Operated Timer

The Jewel No. 11 timer is a synchronous motor powered timer of the repeating interval type. Can be adapted to any time sequence of open and closed circuits over time cycles of sec., min., or hr. Two or more adjustable cams, mounted on a drum, are rotated by the self-starting motor through reduction gears to obtain the time cycle required. The time ratios of open and closed circuits are variable from 95 per cent on and 5 per cent off, to 95 per cent off and 5 per cent on. The motor connections and switch contacts are attached to a bakelite panel which covers the cast



chassis to which the motor and gear train is fastened. Contacts are made of silver. Walser Automatic Timer Co., Graybar Bldg., New York, N. Y.

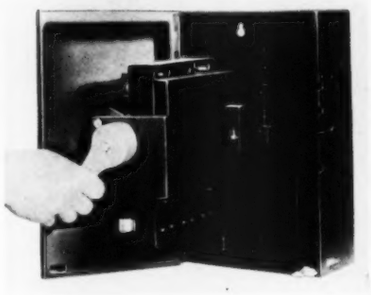
Pulsation Dampener

Is fitted to hydraulic pressure indicating gage, to eliminate vibration of pointer hand under pressure pulsations. For use on production machine tool feeds and hydraulic machinery, the device can be externally adjusted so that the hand moves slowly for major pressure changes, or rapidly to indicate minute pressure pulsations. The standard dampener is made of

bronze for use with pressures up to 10,000 lb. per sq. in., and of steel for higher pressures. It is installed on the gage at the factory, and is not furnished as an attachment. Jas. P. Marsh Corp., 2073 Southport Ave., Chicago, Ill.

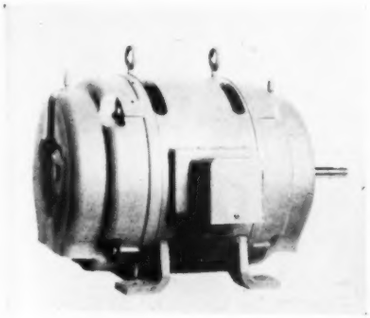
Swing-Out Interior Switches

The swing-out feature permits the entire base and operating mechanism to be swung out and away from the box, providing the entire area for bringing in conduit and wires. After completion of wiring, the base is swung back into normal position and secured by set screws. This feature is incorporated in 30 and 60-amp. type C and general purpose switches and in 50 and 100-amp. industrial circuit breakers. Square D Co., Detroit, Mich.



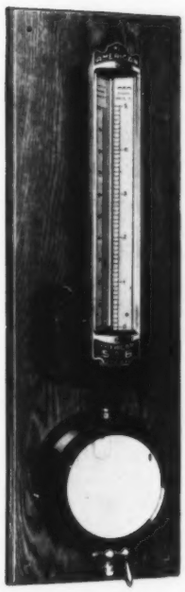
Splash-Proof Motor

Squirrel-cage, splash-proof motor, for constant speed, multi-speed, continuous or intermittent duty. Frames are made of steel and are welded for maximum strength and rigidity. End bells are of gray cast iron. Rotor is mounted on cartridge inclosed ball bearings. The inclosures that shield the inner parts from splash or spray have ventilation openings. Motors are available in all ratings from ½ to 200 hp., in all voltages and cycles and for any torque and starting current. The Imperial Electric Co., Akron, Ohio.

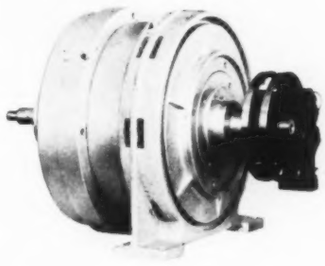


Absolute Pressure Gage

used to measure the actual absolute pressure in an apparatus under vacuum. The gage is direct reading in that the figures on the scale show absolute pressure in the apparatus and not a vacuum reading. Indications are independent of barometric pressure because the entire mercury column is inclosed. Changes in the mercury level in the cistern are compensated for by the foreshortened scale, so that all readings are said to be accurate without the necessity of applying correction factors. The 12-in. silvered scale has black engraved graduations 0 to 10 in. on one side and 0 to 5 lb. on the other in $\frac{1}{10}$ in. and $\frac{1}{10}$ lb. subdivision. American Schaeffer & Budenberg Division of Consolidated Ashcroft Hancock Co., Bridgeport, Conn.

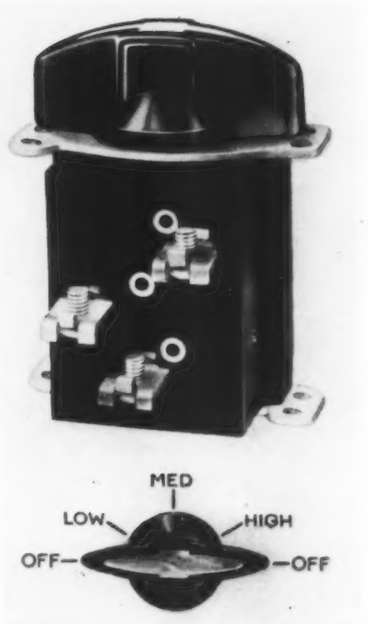


Magnetic Clutch-Brake



The large clutch-brake shown in the illustration is approximately 24 in. in diameter, and develops a clutch torque of 4,500 lb. ft. and a brake torque of 1,500 lb. ft. The brake is mechanically actuated through springs and will stop the drive whenever the electric circuit is opened. There are no wearing parts with the exception of the friction lining. A test conducted on a smaller size of clutch-brake showed in excess of 16,000,000 engagements possible without replacement of the linings. Can be applied to large machine tools such as power presses, bull dozers, rubber and paper, brick and clay making machinery and similar installations. Magnetic Manufacturing Co., Milwaukee, Wis.

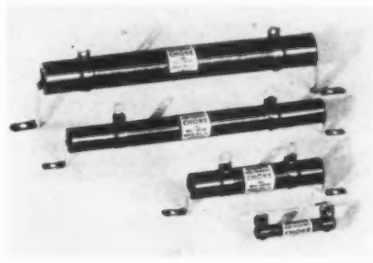
Bi-Rotary Heater Switch



Operates on the slow break principle for the selective control of top plate and oven elements of electric ranges and other heavy-duty electric appliances. This new switch is said to be simpler and more convenient to operate than the old type of switch which it supersedes. The various heats are selected by moving the handle through 45 deg. from each position. Three different mountings are possible with the new type switch. The handle is in modern design, made of bakelite and chromium. The Hart Mfg. Co., Hartford, Conn.

High Frequency Chokes

These plate chokes are used for industrial applications such as therapeutic and diathermy equipment and in electronic tube circuits. The chokes are wound on porcelain tubes and the windings are coated with an insulating material to protect the wires from



moisture and to hold each turn in place. The larger sizes are furnished with non-magnetic mounting brackets, ample space having been allowed to prevent high voltage breakdowns when units are mounted on metal panels. Each of the four sizes of chokes are said to be capable of carrying 1,000 milliamperes without being overloaded. Ohmite Mfg. Co., 4835 W. Flournoy St., Chicago, Ill.

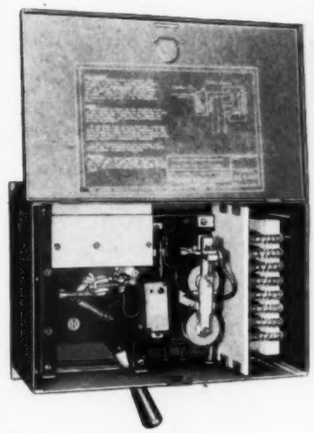
Improved Combustion Safeguard System

The improved Protectoglo for burner equipment includes two separate and distinct types of relays and a flame sensitive electrode. The relays contain standard radio tubes for rectification and amplification of the

power input, which, when conducted from the electrode unit to ground through the flame, operates the relay units controlling the operation sequence, main fuel valve and other units. Any interruption in the circuit to ground through the flame (flame failure) is said to cause instantaneous and positive shut-down. The relays are mounted in a cast iron case, the hinged cover of which is rubber gasketed, making the case dust and moisture-proof. The Brown Instrument Co., Division of Minneapolis-Honeywell Regulator Co., Philadelphia, Pa.

Automatic Motor Starter

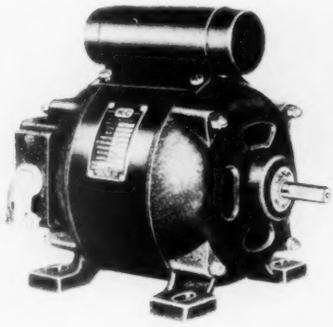
For shunt or compound wound d.c. motors. Uses a relay-type starting mechanism, which starts motor with resistance in and when speed increases throws motor across line. Following an interruption of service or a severe voltage drop, the motor is restarted automatically with resistance in. Overload and short circuit protection are provided. The manufacturer announces the following features of the Improved Type DRT automatic d.c.



starter:—larger case with more clearance, improved resistance element, chrome plated latch rollers and latches, and a moisture-proof non-carbonizing high dielectric panel. Regularly furnished for 250 to 600 volt motors, and 2 to 50 hp. Ohio Brass Co., Mansfield, Ohio.

Capacitor Start Motor

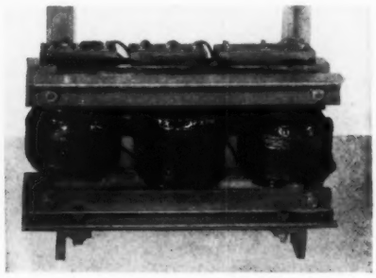
Used for applications where high starting torque is desirable, such as in refrigerators, air compressors, power tools, water pumps and other installations. The condenser is mounted on top of the motor. The terminal box is fitted with a BX-connector and terminals are so arranged for ease of reversing rotation. Motor can be furfurnished with either plain or ball bearings. Available in speeds of 1,740



and 3,450 r.p.m. and in $\frac{1}{6}$, $\frac{1}{4}$, $\frac{1}{3}$ and $\frac{1}{2}$ hp. capacities. Kingston-Conley Electric Co., 66 York St., Jersey City, N. J.

Three-Phase Transformer

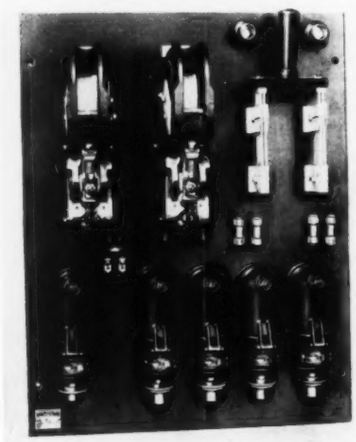
Is for equipment that is moved from place to place where various voltages are used. By the use of this transformer the machine may be arranged with any voltage the manufacturer selects. Voltage changes can be made from 220 to 440 and 550 volts; from 440 to 220 and 550 volts; and from 550 to 220 and 440 volts. The transformer is of the semi-portable type for floor, wall or ceiling mounting. The active parts are attached to steel angles and covered with a steel housing (not



shown). Cooling is by natural circulation. No lubrication is required. Regularly equipped with terminals for 220, 440 and 550 volts, all for three-phase, 60 cycle, although 2 phase and other voltages can be furnished. Available in standard sizes of 1 to 50 kva. the largest size being sufficient for 50 hp. motors. Forbes & Myers, 172 Union St., Worcester, Mass.

Protective Panel for Cranes

For protecting the electrical equipment used on electrically-operated cranes of overhead, locomotive and similar types. The panels are used in place of circuit breakers, knife switches and fuses. All the necessary protective devices are contained in a single



unit. Receptacles for pilot lights are provided. Available in three styles—open, completely inclosed or front-inclosed. The Electric Controller & Mfg. Co., 2700 E. 79th St., Cleveland, Ohio.

MANUFACTURERS' PUBLICATIONS

Anti-Friction Bearing Units — Link Belt Co., 307 N. Michigan Ave., Chicago, Ill. Catalog No. 1520, 40 pages, 6x9 in. Illustrating anti-friction bearing units available in pillow blocks, hanger, takeup, flanged, duplex and special mountings. The various units are mounted either on self-aligning ball bearings, self-aligning roller bearings or tapered roller bearings. The various types of units are also shown in line drawings. Other transmission equipment is also shown.

Automatic Production Control — Reeves Pulley Co., Columbus, Ind. Booklet, 12 pages, 7½x10 in. The booklet discusses automatic speed regulation of industrial production machines and conveyors, telling how automatic regulation is accomplished through the use of various types of Reeves controls in connection with variable speed transmissions. The four types described are hydraulic, mechanical, electric and differential. Numerous installations are shown applicable to machines of various industries.

Callite Contact Points—Callite Products Division, Eisler Electric Corp., 450 39th St., Union City, N. J. Catalog 24 pages, 8½x11 in. Illustrating and listing numerous types of electrical contacts for use in automatic and semi-automatic machines. These contacts are available in tungsten, silver, platinum, molybdenum, tungsten-copper, tungsten-silver and other alloys. The catalog also contains a table giving the approximate current-carrying capacity of contact materials. A number of formed parts and special contacts are also illustrated.

Cartridge Precision Ball Bearings — Norma-Hoffmann Bearings Corp., Stamford, Conn. Bulletin No. F-951, 5 pages, 8½x11 in. The bulletin describes and illustrates the design and uses of extra wide, completely inclosed cartridge type precision ball bearings with removable metal seals, lubricant fittings and shoulder rings. This is a type of ball bearing in which the metal shields which are held in the outer race by snap rings are removable for inspection, cleaning or re-greasing the bearings. Line drawings of typical mountings are also shown.

Cycle Recorder—General Electric Co., Schenectady, N. Y. Folder, GEA 2273, 4 pages, 8x10½ in. Description of inkless cycle recorder for measuring short intervals of time. Illustrations show the inside mechanism. Is used for recording elapsed time as low as 0.01 seconds.

Duraloy Centrifugal Castings—The Duraloy Co., Pittsburgh, Pa. Folder, 4 pages, 8½x11 in. The booklet tells of the contrast in the production of ordinary castings and centrifugal castings in which the advantages of this type of casting are stressed. Parts made from chrome-iron, and chrome-nickel, are sleeves, bushings, rings, seats, liners, burner tubes, conveyor rolls and other tubular shapes. Information is given on machining and welding, also on production facilities.

Gears and Reducers — The Ohio Gear Co., 1333 East 179th St., Cleveland, Ohio—Catalog No. 36, 118 pages, 4½x7 in. The first section of this catalog gives information on gears, racks, couplings, pulleys, cams, and jaw clutches with rules for figuring the various types of gears. Section 2 relates to speed reducers of the single worm, double worm, four speeds, motorized and special types. Line drawings give the important dimensions. In the third section chains and sprockets are dealt with. Eighteen pages of tables of gears, broaches, chains, spline fittings, horsepower torque and heat-treatment are included.

A Guide for Welded Steel Jigs and Fixtures—The Lincoln Electric Co., Cleveland, Ohio. Booklet, 8 pages, 8½x11 in. This booklet will be of interest to jig and fixture designers in that it shows many typical examples of welded steel designs, explaining in many instances the savings in labor and material costs.

Mercury Pressure and Vacuum Gages—American Schaeffer & Budenberg Division of Consolidated Ashcroft Hancock Co., Bridgeport, Conn. Catalog 1350, 11 pages, 7¾x10½ in., showing a line of column pressure gages, absolute pressure gages, mercury column vacuum gages, differential draft and "U" gages. Details of construction, sizes and capacities are listed. Also gives a list of catalogs of instruments for dairies and breweries, and for airplanes and other installations. In this outline of catalogs, valves of all kinds are listed.

Motorized Blowers — Janette Mfg. Co., 556-558 West Monroe St., Chicago, Ill. Bulletin, 4 pages, 8½x11 in. Gives a list of motorized blowers with inclosed motors for industrial applications such as domestic oil burners, coal burning equipment, for ventilation and other applications requiring from 180 to 1,700 cu.ft. per min. of air. The motors used with these blowers are for continuous duty and 40 deg. C. rise with speeds of 1,725 and 3,450 r.p.m. Both flange and foot mountings are available.

Non-return valves — The Edward Valve & Mfg. Co. Inc., East Chicago, Ind. Catalog No. 11-B, 25 pages, 8½x11 in. Showing how to select the correct size of non-return valves, details of design, the choice of materials and the functions of the Edward impactor handwheel. Valves are listed for all standard pressures of from 250 to 1,500 lb. per sq.in. in Ferac metal (high strength cast iron), cast carbon steel, cast carbon molybdenum steel and Evalloy (stainless steel). Cross sectional views are given and dimensions are tabulated. A series of forged steel ston-check valves in sizes from ¼ in. to 2 in. with threaded and flanged ends is included.

Standard Bronze Bushings and Bushings for Replacement—The Bunting Brass & Bronze Co., Toledo, Ohio. Two catalogs 20 and 45 pages respectively 8½x11 in. The first catalog lists many bearings of the sleeve type ¼ in. to 4 in. inside diameter and ⅜ in. to 4½ in. outside diameter in lengths up to 7 in. A list of graphited bronze oilless bearings is also included. Information is given on machined and centered bronze bars, and anti-friction industrial babbit. Photographs illustrate various types of sleeve bearings.

In the second catalog there are 31 pages of alphabetical listings of electric motor bushings that are available for replacement or for new designs. Also a list of the popular sizes of electric fan motor bearings. Standard types of oil grooves are also shown.

Standards for Socket Set and Cap Screws — Holo-Krome Screw Corp., Bristol, Conn. Booklet, 8 pages, 8½x11 in. This booklet contains standards for hexagonal type socket set and cap screws as approved by the American Standards Association and sponsored by the Society of Automotive Engineers and the American Society of Mechanical Engineers. Included are all dimensions of heads, bodies, screw and thread lengths, screw points, sizes of sockets and wrenches. Formulas for dimensions and tolerances are also included. Designers, engineers and draftsmen wishing a copy for reference may obtain one from the above concern, referring to the booklet as H.K. 166. There is no charge.

Thiokol Facts—Thiokol Corp., Yardville, N. J. Announcement is made of a new house organ which will make its appearance every other month under the caption of "Thiokol Facts" containing specific information on new Thiokol applications. In volume No. 1 for April, the subject of the article is "A Rubber Plantation in New Jersey" which tells of the making of Thiokol and the industries in which the material is used. A series of photographs illustrate the various operations in the manufacture of this synthetic rubber.

Thwing's Paper Tester—Thwing-Albert Instrument Co., 3339 Lancaster Ave., Philadelphia, Pa. Vol. No. 1 of a new house organ, which will be published every two months, has made its appearance. In this first issue the technique of checking on basis weight of paper is fully discussed. Subsequent issues will deal with additional topics of interest to manufacturers, converters, buyers and users of paper and paper products. It is announced that these articles will be written by outstanding authorities in the paper industry and written so that the average non-technical reader can understand them. The publication is illustrated with photographs and tables.

"Why Ohio Motors Are Reliable"—The Ohio Electric Mfg. Co., 5900 Maurice Ave., Cleveland, Ohio. Bulletin, 16 pages, 9x12 in. A pictorial presentation of some of the manufacturing operations used in building Ohio fractional horsepower motors. These pictures illustrate burnishing the bearings, various tests, balancing of rotating parts, punch and die work for motor laminations, heat-treating and final inspection and running tests.

BOOKS AND BULLETINS

Principles of Mechanism

S. Dyson. 316 pages, 5½ x 8½ in. Blue clothboard cover. Published by the Oxford University Press, 114 Fifth Ave., New York, N. Y. Price $4.25.

Other than minor changes and corrections, and the addition of sections on viscous friction and controlling force diagrams for governors, this second edition is substantially the same as the first which was published in 1928.

Written primarily to meet the needs of the students, the book presents the fundamental principles of the theory of mechanisms in a comprehensive manner. After developing the fundamental principles, the author takes up their application to specific machine elements such as the slider crank chain, gear wheels, wheel combinations, belts and ropes, flywheels, governors and cams. A chapter is devoted to friction. Numerous worked-out examples and problems with answers given, add much to the book which is well written throughout.

Photo-Electric and Selenium Cells

T. J. Fielding. 138 pages, 4½x7½ in. 74 illustrations. Blue clothboard covers. Published by Instruments Publishing Co., 1117 Wolfendale St., Pittsburgh, Pa. Price $1.75.

Fundamentals of photo-electric cells, circuits and applications are presented in a manner that will not be over the head of any practical man. This book is not a reference text, but is more of an introduction to the subject. Many of the applications described are of principal interest to the amateur experimenter, but serve very well to demonstrate practical uses. Methods of making selenium cells are described in detail.

Mathematics of Modern Engineering

Robert E. Doherty and *Ernest G. Keller.* 299 pages. 5½x9 in. Blue clothboard covers. Published by John Wiley & Sons, Inc., 440 Fourth Ave., New York, N. Y. Price $3.50.

This book is one of a series written in the interest of the advance course in engineering of the General Electric Company, as stated on the title page. It is not a textbook for those who wish to learn calculus and analytical mechanics for it is written on the assumption that the reader is well acquainted with the advanced mathematics. It is termed by the authors as a "handbook on engineering mathematics . . . , a guide in bridging the gap of engineering between physics and mathematics by the scientific method . . . , A presentation suitable for engineers, of those aspects of mathematics which the experience of a large manufacturing organization dealing with the electrical and mechanical problems has indicated to be of value to engineers."

After a discussion in the first chapter of the procedure in formulating a problem in mathematical terms, the book takes up the mathematical solution of engineering problems that require the application of ordinary differential equations with constant coefficient. Vibration problems and problems relating to simple electric circuits are covered. The authors then take up Laplace's expansion, determinants, Fourier series, the solution of higher degree and transcendental equations, dimensional analysis, graphical and numerical methods of solving differential equations. Other chapters cover vector analysis and the derivation of the partial differential equations of mathematical physics or vector fields.

In the concluding chapter are given some typical engineering problems that are solved by higher mathematics, complex numbers and functions, Green's formula, Taylor's Series, Laurent's expansion, etc. The text concludes with the detailed solution of some typical engineering problems that require calculus of a higher order.

Elements of Diesel Engineering

Orville Adams, 478 pages, 6x9 in., 284 illustrations. Red clothboard covers. Published by The Norman W. Hendley Publishing Co., 2 West 45th St., New York, N. Y. Price $4.

This manual is a comprehensive treatise of the diesel engine for stationary, marine, automotive and locomotive use. The book is divided into 20 chapters, beginning with the historical development of this type of engine. Forty pages are devoted to the elements of diesel operation, giving standard definitions and efficiency factors. Several chapters deal with fuel injection and combustion chambers going into detail on nozzles, pumps and spray valves, and fuels used. Three chapters cover all the phases relating to pistons and piston rings, cylinders and liners and major bearing construction. Fifteen pages of diesel lubricating oils are quite complete. There is a section on air intake and exhaust systems. Twenty-two pages tell of high speed diesel development in Europe and there are chapters on the development of high speed engines for trucks and tractors and operation and maintenance of automotive diesel engines, auxiliaries and accessories. There are numerous questions with answers at the end of each chapter. A 26 page index completes the book.

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Silcrome Stainless Steel

New Ways to Increase Sales and Profits with Silcrome Stainless Steel. Ludlum Steel Co., Watervliet, N. Y. Booklet, 28 pages, 8½x11 in. Varnished paper covers.

A pictorial presentation of the uses of rust, stain and acid resisting steel depicting many applications in the home, in food manufacturing plants and for hotels, restaurants and hospitals. Also how Silcrome is used in architectural construction, in the process industries, in transportation, for metal working, hardware and wire products.

The booklet is profusely illustrated with photographs of furniture, dishes, cutlery and cooking utensils. In bakeries this steel is used for the fabrication of ovens, mixers and weighing machines, while in dairies coolers, filters, pasteurizers, tanks and coils are made of this material. Because of its resistance to heat and corrosion, automobile valves, body trim and hardware are examples of its use. Other parts made of Silcrome are conveyor parts, bolts, nuts, nails, screws, pins and washers, springs, screens, wire rope, and marine and airplane rigging.

Tenite

Tennessee Eastman Corp., Kingsport, Tenn. Booklet, Edition 3A, 52 pages, 7x10 in. Laminated cellulose acetate covers.

Claimed to be the most complete manual on cellulose acetate plastics, the booklet contains not only examples made of this material, but also a comprehensive section on the relatively new process of injection molding. Well illustrated with fine photographs, many applications are shown which include steering wheels, window regulator handles and numerous fittings for automobiles, building hardware, goggle frames, fishing reels, valve handles, lamp housings, oil cups, radio grilles, telephones, typewriter keys, film cores, knife handles, fountain pen barrels, vanity cases, costume jewelry and combs.

Data on compression molding are given with designs of molds. A piping diagram for steam and water as used in the press is also shown. Nine pages of text and line drawings are devoted to the process of injection molding giving step-by-step procedure. Injection molding machines are described and the design of molds is explained and illustrated with cross-section line drawings. Machining and finishing characteristics of Tenite are discussed in detail and physical properties are also included.

Equations for Ohm's Law and a Chart for Their Solution

R. C. HITCHCOCK

OHM'S Law for direct current circuits is usually remembered as $E = IR$, and $W = EI$, in which E is the voltage, I is the current in amp., R is the resistance in ohms, and W is the power in watts. Actually twelve different combinations of these four quantities are possible as shown in the accompanying table.

To engineers who revert to the basic Ohm's Law formulas each time an unfamiliar problem is presented, the actual picture of the relations of the quantities involved is seldom clear-cut. As an example, the relation giving the maximum allowable voltage on a resistor whose wattage rating and resistance are known is $E = \sqrt{WR}$. On the chart on the next page this relation is easily comprehended and useful values are quickly obtained.

Readings are taken from the chart with a single application of a straight edge. This indicates that any two of the four quantities, volts, watts, amperes, and ohms, completely determines the remaining two quantities.

When one of the quantities is a fixed value, variable conditions are rapidly and accurately portrayed by pivoting the straight edge at the fixed quantity and then moving about this pivot. For a 5 ohm resistor, the relations of the other three quantities are found by pivoting a straight edge at this 5 ohm point on the right-hand scale. With a fixed potential of 50 volts, (dotted line *a*) the wattage dissipation is 500 watts, and the corresponding current value is 10 amp. Thus, the resistor should have a watt rating of 500 to stand the 50 volt potential. Still using the same 5 ohms resistance and aligning with 5 volts (dotted line *b*) shows that the resistor can dissipate only 5 watts, and the corresponding current is 1 amp. Thus for a given 5 ohm resistor, when the voltage changes from 50 to 5, the wattage changes from 500 to 5, and the corresponding current values are 10 and 1 amp., respectively.

When any one of the four quantities is held constant, only one other quantity can be varied. Once the limits of this single variable are determined the related quantities are shown immediately from the chart by using a straight edge.

As another example, determine the range of voltage, current, and resistance allowable in a resistor having a fixed wattage rating of 50 watts. The 50 watt point on the second column from the left is used as a pivot about which a straight edge is moved to cut the other scales. If 10 volts is applied to this 50 watt resistor the dashed line *c* shows that the current flowing will be 5 amp. and the resistance will be 2 ohms. Line *d* shows that 50 volts will produce a current of 1 amp. if the resistance is 50 ohms. The 2 and 50 ohm values of resistance are for two different resistors, of course.

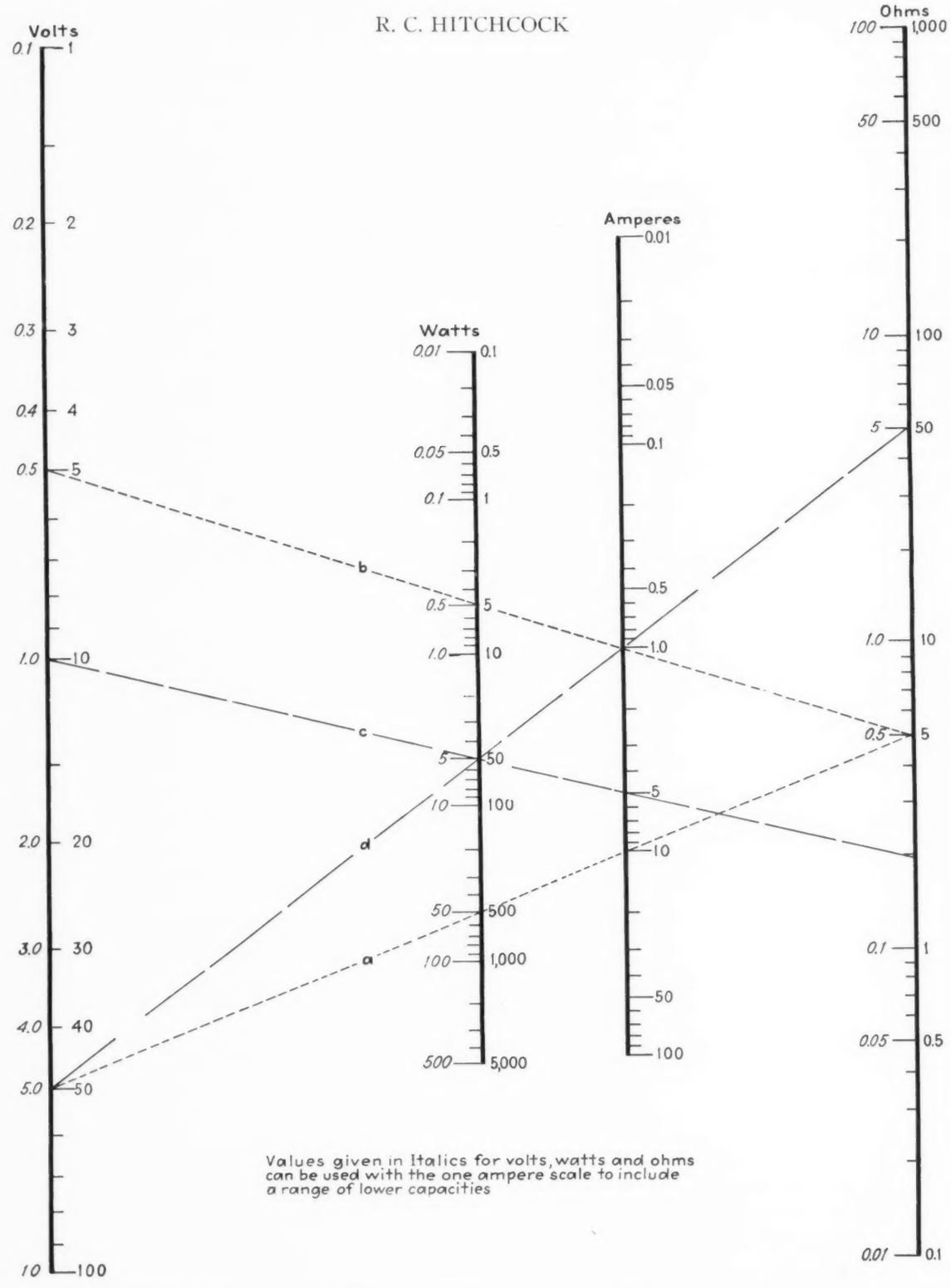
As the watt rating of a resistor is a function of radiating area, the current in a variable resistor, partly used, is the same as for the total resistor. That is, if the 2 ohm resistor (line *d*) was variable, then 5 amperes can be passed through it at any point. The watt dissipation, however, would vary with the length of the resistor used.

DIFFERENT FORMS OF OHM'S LAW

	Various Electric Units in Terms Of					
	EI	ER	RI	WE	WI	WR
Watts, W =	EI	$\frac{E^2}{R}$	RI^2			
Volts, E =			RI		$\frac{W}{I}$	$\sqrt{WR}$
Amperes, I =		$\frac{E}{R}$		$\frac{W}{E}$		$\sqrt{\frac{W}{R}}$
Ohms, R =	$\frac{E}{I}$			$\frac{E^2}{W}$	$\frac{W}{I^2}$	

Chart for Solving Ohm's Equations

R. C. HITCHCOCK



Values given in Italics for volts, watts and ohms can be used with the one ampere scale to include a range of lower capacities

PRODUCT ENGINEERING © REFERENCE BOOK SHEET

CLASSIFIED DIRECTORY

Electric and Hydraulic Drives, Controls and Accessories Manufacturers

Electric Motors, Controls, Accessories

Bold face denotes companies advertising in this issue

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Century Electric Co., St. Louis, Mo.
Clark Controller Co., 1146 East 152 St. Cleveland, Ohio
Continental Electric Co., Inc., 325 Ferry St., Newark, N. J.
Cutler-Hammer, Inc., 569 N. Twelfth St., Milwaukee, Wis.
Electric Controller & Mfg. Co., 2700 East 79th St., Cleveland, Ohio
Electric Specialty Co., 211 South St., Stamford, Conn.
General Electric Co., Schenectady, N. Y.
Harnischfeger Corp., 4400 W. National Ave., Milwaukee, Wis.
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CONTROLLERS, MOTOR

Allen-Bradley Co., 1326 S. 2nd St., Milwaukee, Wis.
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Anderson & Co., C. J., 212-222 W. Austin Ave., Chicago, Ill.
Arrow-Hart & Hegeman Electric Co., Hartford, Conn.
Bender Warrick Corp., 131 Pierce St., Birmingham, Mich.
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Electric Controller & Mfg. Co., 2700 East 79th St., Cleveland, Ohio
Electric & Mfg. Co., Euclid, Ohio
Fairbanks, Morse & Co., 900 S. Wabash Ave., Chicago, Ill.
Furnas Electric Co., 811 South 72nd St., West Allis, Wis.
General Electric Co., Schenectady, N. Y.
Ideal Electric & Mfg. Co., Mansfield, Ohio
Lincoln Electric Co., 12818 Coit Rd., Cleveland, Ohio
Monitor Controller Co., 51 S. Gay St., Baltimore, Md.
Ohio Brass Co., Mansfield, Ohio
Ranco, 6th & Indianola Ave., Columbus, Ohio
Roller-Smith Co., 233 Broadway, New York, N. Y.
Rowan Controller Co., 2315 Homewood Ave., Baltimore, Md.
Safety Car Heating & Lighting Co., New Haven, Conn.
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Trumbull Electric Mfg. Co., Plainville, Conn.
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Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

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General Electric Co., Schenectady, N. Y.
Rhodes, Inc., M. H., 1270 Sixth Ave., New York, N. Y.
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ELECTRONIC DEVICES

Allen-Bradley Co., 1326 S. 2nd St., Milwaukee, Wis.
American Instrument Co., 8010 Georgia Ave., Silver Spring, Md.
Automatic Electric Co., 1033 W. Van Huron St., Chicago, Ill.
Continental Electric Co., St. Charles, Ill.
Cutler-Hammer, Inc., 569 N. Twelfth St., Milwaukee, Wis.
Dunn, Inc., Struthers, 135 N. Juniper St., Philadelphia, Pa.
Electric Valve Mfg. Co., 64 Murray St., New York, N. Y.
General Electric Co., Schenectady, N. Y.
General Radio Co., 30 State St., Cambridge, Mass.
G-M Laboratories, Inc., 1731 Belmont Ave., Chicago, Ill.
Kurman Electric Co., Inc., 241 Lafayette St., New York, N. Y.
Minneapolis-Honeywell Regulator Co., 2748 Fourth Ave. South, Minneapolis, Minn.
Ward Leonard Electric Co., 31 South St., Mount Vernon, N. Y.
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.
Weston Electrical Instrument Corp., 614 Frelinghuysen Ave., Newark, N. J.

INSTRUMENTS

American Instrument Co., 8010 Georgia Ave., Silver Spring, Md.
Bendix Marine Products Co., 754 Lexington Ave., Brooklyn, N. Y.
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Brown Instrument Co., Philadelphia, Pa.
Continental Electric Co., St. Charles, Ill.
Dunn, Inc., Struthers, 138 North Juniper, Philadelphia, Pa.
Friez & Sons, Inc., Julien P., Baltimore St. & Central Ave., Baltimore, Md.
General Electric Co., Schenectady, N. Y.
General Radio Co., 30 State St., Cambridge, Mass.
G-M Laboratories, Inc., 1731 Belmont Ave., Chicago, Ill.
H-B Instrument Co., Inc., 2518 North Broad St., Philadelphia, Pa.

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Minneapolis-Honeywell Regulator Co., 2748 Fourth Ave. South, Minneapolis, Minn.
Partlow Corp., New Hartford, N. Y.
Roller-Smith Co., 233 Broadway, New York, N. Y.
Spencer Thermostat Co., 34 Forest St., Attleboro, Mass.
Tagliabue Mfg. Co., C. J., Park & Nostrand Aves., Brooklyn, N. Y.
Taylor Instrument Co., Rochester, N. Y.
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Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.
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Wilbin Instrument Corp., 40 E. 34th St., New York, N. Y.

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• Fractional to 2 Horsepower

Advance Electric Co., 6315 Maple Ave., St. Louis, Mo.
Allis Co., Louis, 427 E. Stewart St., Milwaukee, Wis.
Apex Electrical Mfg. Co., 1070 E. 152nd St., Cleveland, Ohio
Armor Electric Mfg. Co., 1020 Holland St., Erie, Pa.
Baldor Electric Co., 4351-63 Duncan Ave., St. Louis, Mo.
Barber-Colman Co., Rockford, Ill.
Black & Decker Electric Co., Lake St., Kent, Ohio
Bodine Electric Co., 2254 W. Ohio St., Chicago, Ill.
Brown-Brockmeyer Co., Dayton, Ohio
Burke Electric Co., Erie, Pa.
Cedarburg Mfg. Co., Cedarburg, Wis.
Century Electric Co., St. Louis, Mo.
Clements Mfg. Co., Chicago, Ill.
Cleveland Electric Motor Co., 5213 Chester Ave., Cleveland, Ohio
Continental Electric Co., Inc., 325 Ferry St., Newark, N. J.
Crocker-Wheeler Electric Mfg. Co., Ampere, N. J.
Delco Appliance Corp., 391 Lyell Ave., Rochester, N. Y.
Delco Products Corp., Dayton, Ohio
Diehl Mfg. Co., Elizabethport, N. J.
Dumore Co., 14th & Racine Sts., Racine, Wis.
Electric Motor Corp., 401 Lake Ave., Racine, Wis.
Electric Products Co., Cleveland, Ohio
Electric Specialty Co., 211 South St., Stamford, Conn.
Elliott Co., Jeannette, Pa.
Emerson Electric Mfg. Co., 2012-2032 Washington Ave., St. Louis, Mo.
Ermstat Co., 1825-39 Wylie St., Philadelphia, Pa.
Fairbanks, Morse & Co., 900 S. Wabash Ave., Chicago, Ill.
Fidelity Electric Co., 332 N. Arch St., Lancaster, Pa.
Forbes & Myers, 172 Union St., Worcester, Mass.
General Electric Co., Schenectady, N. Y.
General Industries Co., Elyria, Ohio
Gilbert Co., The A. C., Blatchley Ave., New Haven, Conn.
Hamilton Beach Co., Racine, Wis.
Hansen Mfg. Co., Princeton, Ind.
Harnischfeger Corp., 4400 W. National Ave., Milwaukee, Wis.
Holtzer-Cabot Electric Co., 125 Amory Street, Boston, Mass.
Howell Electric Motors Co., Howell, Mich.
Imperial Electric Co., Akron, Ohio
Janette Mfg. Co., 556 W. Monroe St., Chicago, Ill.
Kendrick & Davis, Lebanon, N. H.
Kingston-Conley Electric Co., Jersey City, N. J.
Leland Electric Co., 1501 Webster St., Dayton, Ohio
Lincoln Electric Co., 12818 Coit Rd., Cleveland, Ohio
Marathon Electric Mfg. Co., Wausau, Wis.
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Master Electric Co., 100 Davis Ave., Dayton, Ohio
Minneapolis-Honeywell Regulator Co., 2748 Fourth Ave. South, Minneapolis, Minn.
Northwestern Electric Co., Chicago, Ill.
Ohio Electric Mfg. Co., 5911 Maurice Ave., Cleveland, Ohio
Peerless Electric Co., 2100 W. Market St., Warren, Ohio
Pioneer Gen-E-Motor Corp., Chicago, Ill.
Redmond Co., A. G., Flint, Mich.
Reliance Electric & Engineering Co., Cleveland, Ohio
Reynolds Electric Co., Chicago, Ill.
Robbins & Myers, Inc., Springfield, Ohio
Russell Electric Co., 340 West Huron Street, Chicago, Ill.
Signal Electric Mfg. Co., Menominee, Mich.
Smith Mfg. Co., F. A., Rochester, N.Y.
SpeedWay Mfg. Co., 1828 S. 52nd Ave., Cicero, Ill.
Star Electric Motor Co., Bloomfield Ave. & Grove St., Bloomfield, N. J.
Sterling Electric Motors, Inc., Los Angeles, Cal.
Stow Mfg. Co., Inc., 443 State St., Binghamton, N. Y.
Sturtevant Co., B. F., Damon St., Hyde Park, Boston, Mass.
United Electrical Mfg. Co., Adrian, Mich.
U. S. Electrical Motors, Inc., Los Angeles, Cal.
Valley Electric Corp., St. Louis, Mo.
Victor Electric Products Inc., 712 Reading Rd., Cincinnati, Ohio
Wagner Electric Corp., 6400 Plymouth Ave., St. Louis, Mo.
Warren Telechron Co., Ashland, Mass.
Wesche Electric Co., B. A., Cincinnati, Ohio
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.
Woods Machine Co., S. A., Boston, Mass.
Yates American Machine Co., Beloit, Wis.
Zobell Electric Motor Corp., South Avenue, Garwood, N. J.

MOTORS

• Over 2 Horsepower

Advance Electric Co., St. Louis, Mo.
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Allis Co., Louis, 427 E. Stewart St., Milwaukee, Wis.
Armor Electric Mfg. Co., 1020 Holland St., Erie, Pa.
Baldor Electric Co., 4351-63 Duncan Ave., St. Louis, Mo.
Brown-Brockmeyer Co., Dayton, Ohio
Burke Electric Co., Erie, Pa.
Century Electric Co., St. Louis, Mo.
Chandeysson Electric Co., St. Louis, Mo.
Cleveland Electric Motor Co., 5213 Chester Ave., Cleveland, Ohio
Continental Electric Co., Inc., 325 Ferry St., Newark, N. J.
Crocker-Wheeler Electric Mfg. Co., Ampere, N. J.
Delco Products Corp., Dayton, Ohio
Diehl Mfg. Co., Elizabethport, N. J.
Electric Machinery Mfg. Co., Minneapolis, Minn.
Electric Products Co., Cleveland, Ohio
Electric Specialty Co., 211 South St., Stamford, Conn.
Electro Dynamic Works, Ave. A and North St., Bayonne, N. J.
Elliott Co., Jeannette, Pa.
Emerson Electric Mfg. Co., 2012-2032 Washington Ave., St. Louis, Mo.
Fairbanks, Morse & Co., 900 S. Wabash Ave., Chicago, Ill.
Fidelity Electric Co., 332 N. Arch St., Lancaster, Pa.
Forbes & Myers, 172 Union St., Worcester, Mass.
General Electric Co., Schenectady, N. Y.
Harnischfeger Corp., 4400 West National Ave., Milwaukee, Wis.
Hertner Electric Co., 12690 Elmwood Ave., Cleveland, Ohio
Howell Electric Motors Co., Howell, Mich.
Ideal Electric & Mfg. Co., 410 E. 1st St., Mansfield, Ohio
Imperial Electric Co., Akron, Ohio
Janette Mfg. Co., 556 W. Monroe Street, Chicago, Ill.
Kimble Electric Co., 2007 W. Hastings St., Chicago, Ill.
Leland Electric Co., Dayton, Ohio
Lincoln Electric Co., 12818 Coit Rd., Cleveland, Ohio
Marble-Card Electric Co., Gladstone, Mich.
Master Electric Co., 100 Davis Ave., Dayton, Ohio
Ohio Elec. Mfg. Co., 5911 Maurice Ave., Cleveland, Ohio
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Reliance Electric & Engineering Co., 1088 Ivanhoe Rd., Cleveland, Ohio
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Sterling Electric Motors, Inc., Los Angeles, Cal.
Stow Mfg. Co., Inc., 443 State Street, Binghamton, N. Y.
Sturtevant Co., B. F., Damon St., Hyde Park, Boston, Mass.
U. S. Electrical Mfg. Co., Los Angeles, Cal.
Valley Electric Corp., St. Louis, Mo.
Wagner Electric Corp., 6400 Plymouth Ave., St. Louis, Mo.
Walter Electric Mfg. Co., Norfolk, Va.
Wesche Electric Co., B. A., Cincinnati, Ohio
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.
Woods Machine Co., S. A., Boston, Mass.
Yates American Machine Co., Beloit, Wis.
Zobell Electric Motor Corp., South Avenue, Garwood, N. J.

MOTORS

• Semi-Inclosed

Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Allis Co., Louis, 427 E. Stewart St., Milwaukee, Wis.
Armor Electric Mfg. Co., 1020 Holland St., Erie, Pa.
Baldor Electric Co., 4351-63 Duncan Ave., St. Louis, Mo.
Black & Decker Electric Co., Lake St., Kent, Ohio
Bodine Electric Co., 2254 W. Ohio St., Chicago, Ill.
Burke Electric Co., Erie, Pa.
Century Electric Co., St. Louis, Mo.
Cleveland Electric Motor Co., 5213 Chester Ave., Cleveland, Ohio
Continental Electric Co., Inc., 325 Ferry St., Newark, N. J.
Crocker-Wheeler Electric Mfg. Co., Ampere, N. J.
Delco Appliance Corp., 391 Lyell Ave., Rochester, N. Y.
Diehl Mfg. Co., Elizabethport, N. J.
Dumore Co., 14th & Racine Sts., Racine, Wis.
Electric Motor Corp., 401 Lake Ave., Racine, Wis.
Electric Specialty Co., 211 South St., Stamford, Conn.
Electro Dynamic Works, Ave. A and North Street, Bayonne, N. J.
Emerson Electric Mfg. Co., 2012-2032 Washington Ave., St. Louis, Mo.
Fairbanks, Morse & Co., 900 S. Wabash Ave., Chicago, Ill.
Fidelity Electric Co., 332 N. Arch St., Lancaster, Pa.
Forbes & Myers, 172 Union St., Worcester, Mass.
General Electric Co., Schenectady, N. Y.
Gilbert Co., The A. C., Blatchley Ave., New Haven, Conn.
Harnischfeger Corp., 4400 West National Ave., Milwaukee, Wis.
Holtzer-Cabot Electric Co., 125 Amory Street, Boston, Mass.
Howell Electric Motors Co., Howell, Mich.
Ideal Electric & Mfg. Co., 410 E. 1st St., Mansfield, Ohio
Janette Manufacturing Co., 556 W. Monroe St., Chicago, Ill.
Kendrick & Davis, Lebanon, N. H.
Kingston-Conley Electric Co., Jersey City, N. J.
Leland Electric Co., 1501 Webster St., Dayton, Ohio
Lincoln Electric Co., 12818 Coit Rd., Cleveland, Ohio
Marble-Card Electric Co., Gladstone, Mich.
Master Electric Co., 100 Davis Ave., Dayton, Ohio
Ohio Elec. Mfg. Co., 5911 Maurice Ave., Cleveland, Ohio
Peerless Electric Co., 2100 W. Market St., Warren, Ohio
Reliance Electric & Engineering Co., 1088 Ivanhoe Rd., Cleveland, Ohio
Signal Electric Mfg. Co., Menominee, Mich.
Star Electric Motor Co., Bloomfield Ave. & Grove St., Bloomfield, N. J.
Sterling Electric Motors, Inc., Los Angeles, Cal.
Stow Mfg. Co., Inc., 443 State St., Binghamton, N. Y.
Sturtevant Co., B. F., Damon St., Hyde Park, Boston, Mass.
Victor Electric Products Inc., 712 Reading Rd., Cincinnati, Ohio
Wagner Electric Corp., 6400 Plymouth Ave., St. Louis, Mo.
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.
Yates American Machine Co., Beloit, Wis.
Zobell Electric Motor Corp., South Ave., Garwood, N. J.

MOTORS

• Totally Inclosed

Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Allis Co., Louis, 427 E. Stewart Street, Milwaukee, Wis.
Armor Electric Mfg. Co., 1020 Holland St., Erie, Pa.
Baldor Electric Co., 4351-63 Duncan Ave., St. Louis, Mo.
Bodine Electric Co., 2254 W. Ohio St., Chicago, Ill.
Brown-Brockmeyer Co., Dayton, Ohio
Burke Electric Co., Erie, Pa.
Century Electric Co., St. Louis, Mo.
Cleveland Electric Motor Co., 5213 Chester Ave., Cleveland, Ohio.
Continental Electric Co., Inc., 325 Ferry St., Newark, N. J.
Crocker-Wheeler Electric Mfg. Co., Ampere, N. J.
Delco Appliance Corp., 391 Lyell Ave., Rochester, N. Y.
Diehl Mfg. Co., Elizabethport, N. J.
Dumore Co., 14th & Racine Sts., Racine, Wis.
Electric Motor Corp., 401 Lake Ave., Racine, Wis.
Electric Specialty Co., 211 South St., Stamford, Conn.
Electro Dynamic Works, Ave. A and North St., Bayonne, N. J.
Emerson Electric Mfg. Co., 2012-2032 Washington Ave., St. Louis, Mo.
Fairbanks, Morse & Co., 900 S. Wabash Ave., Chicago, Ill.
Fidelity Electric Co., 332 N. Arch St., Lancaster, Pa.
Forbes & Myers, 172 Union St., Worcester, Mass.
General Electric Co., Schenectady, N. Y.
Harnischfeger Corp., 4400 West National Ave., Milwaukee, Wis.
Holtzer-Cabot Electric Co., 125 Amory St., Boston, Mass.
Howell Electric Motors Co., Howell, Mich.
Ideal Electric & Mfg. Co., 410 E. 1st Street, Mansfield, Ohio
Imperial Electric Co., Akron, Ohio
Janette Mfg. Co., 556 W. Monroe St., Chicago, Ill.
Kingston-Conley Electric Co., Jersey City, N. J.
Leland Electric Co., 1501 Webster St., Dayton, Ohio
Lincoln Electric Co., 12818 Coit Rd., Cleveland, Ohio
Marble-Card Electric Co., Gladstone, Mich.
Master Electric Co., 100 Davis Ave., Dayton, Ohio
Ohio Electric Mfg. Co., 5911 Maurice Ave., Cleveland, Ohio
Peerless Electric Co., 2100 W. Market St., Warren, Ohio
Reliance Electric & Engineering Co., 1088 Ivanhoe Road, Cleveland, Ohio
Robbins & Myers, Inc., Springfield, Ohio
Signal Electric Mfg. Co., Menominee, Mich.
Star Electric Motor Co., Bloomfield Ave. & Grove St., Bloomfield, N. J.
Sterling Electric Motors, Inc., Los Angeles, Cal.
Stow Mfg. Co., Inc., 443 State St., Binghamton, N. Y.
Sturtevant Co., B. F., Damon St., Hyde Park, Boston, Mass.
U. S. Electrical Mfg. Co., Los Angeles, Cal.
Wagner Electric Corp., 6400 Plymouth Ave., St. Louis, Mo.
Warren Telechron Co., Ashland, Mass.
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.
Yates American Machine Co., Beloit, Wis.
Zobell Electric Motor Corp., South Ave., Garwood, N. J.

MOTORS

• Speed Reducers Built In

Abart Gear & Machine Co., 4833 W. 16th St., Chicago, Ill.
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Allis Co., Louis, Milwaukee, Wis.
Armor Electric Mfg. Co., 1020 Holland St., Erie, Pa.
Barber-Colman Co., Rockford, Ill.
Bodine Electric Co., 2254 W. Ohio St., Chicago, Ill.
Century Electric Co., St. Louis, Mo.
Cleveland Electric Motor Co., 5213 Chester Ave., Cleveland, Ohio.
Continental Electric Co., Inc., 325 Ferry St., Newark, N. J.
Crocker-Wheeler Electric Mfg. Co., Ampere, N. J.
Diehl Mfg. Co., Elizabethport, N. J.
Dumore Co., Racine, Wis.
Earle Gear & Machine Co., Philadelphia, Pa.
Electric Motor Corp., 401 Lake Ave., Racine, Wis.
Electric Specialty Co., 211 South St., Stamford, Conn.
Electro Dynamic Works, Ave. A and North St., Bayonne, N. J.
Emerson Electric Mfg. Co., 2012-2032 Washington Ave., St. Louis, Mo.
Fairbanks, Morse & Co., 900 S. Wabash Ave., Chicago, Ill.
Falk Corp., Milwaukee, Wis.
Foote Gear Works, Inc., Cicero, Ill.
General Electric Co., Schenectady, N. Y.
Gilbert Co., The A. C., Blatchley Ave., New Haven, Conn.
Howell Electric Motors Co., Howell, Michigan
Ideal Electric & Mfg. Co., 410 E. 1st St., Mansfield, Ohio
Janette Mfg. Co., 556 W. Monroe St., Chicago, Ill.
Kendrick & Davis, Lebanon, N. H.
Leland Electric Co., 1501 Webster St., Dayton, Ohio
Master Electric Co., 100 Davis Ave., Dayton, Ohio
Minneapolis-Honeywell Regulator Co., 2748 Fourth Ave. South, Minneapolis, Minn.
New Departure Mfg. Co., Bristol, Conn.
Reliance Electric & Engineering Co., 1088 Ivanhoe Road, Cleveland, Ohio
Shepard Niles Crane & Hoist Corp., Montour Falls, N. Y.
Signal Electric Co., Menominee, Mich.
Silent Hoist Winch & Crane Co., 762-772 Henry Street, Brooklyn, N. Y.
SpeedWay Mfg. Co., 1828 So. 52nd Ave., Cicero, Ill.
Star Electric Motor Co., Bloomfield Ave. & Grove St., Bloomfield, N. J.
Sterling Electric Motors, Inc., Los Angeles, Cal.

Stow Mfg. Co., Inc., 443 State St., Binghamton, N. Y.
Universal Gear Corp., Indianapolis, Ind.
U. S. Electrical Mfg. Co., Los Angeles, Cal.
Wagner Electric Corp., 6400 Plymouth Ave., St. Louis, Mo.
Warren Telechron Co., Ashland, Mass.
Watson-Flagg Machine Co., Inc., 845 E. 25th St., Paterson, N. J.
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

RELAYS

Allen-Bradley Co., 1326 S. 2nd St., Milwaukee, Wis.
American Instrument Co., 8010 Georgia Ave., Silver Spring, Md.
Anderson & Co., C. J., 212-222 W. Austin Ave., Chicago, Ill.
Arrow-Hart & Hegeman Electric Co., Hartford, Conn.
Automatic Electric Co., 1033 W. Van Huron St., Chicago, Ill.
Automatic Products Co., 121 N. Broadway, Milwaukee, Wis.
Automatic Switch Co., 154 Grand St., New York, N. Y.
Bender Warrick Corp., 131 Pierce St., Birmingham, Mich.
Bendix Marine Products Co., 754 Lexington Ave., Brooklyn, N. Y.
Carrick Engineering Corp., Michigan City, Ind.
Clark Controller Co., 1146 East 152 St., Cleveland, Ohio
Continental Electric Co., St. Charles, Ill.
Cutler-Hammer, Inc., 569 N. Twelfth St., Milwaukee, Wis.
Dunn, Inc., Struthers, 138 North Juniper, Philadelphia, Pa.
Eagle Signal Corp., 202 20th St., Moline, Ill.
Edison, Inc., Thomas A., 45 Lakeside Ave., West Orange, N. J.
Electric Controller & Mfg. Co., 2700 East 79th St., Cleveland, Ohio
Fidelity Electric Co., 332 N. Arch St., Lancaster, Pa.
Friez & Sons, Julien P., Baltimore St. & Central Ave., Baltimore, Md.
Gamewell Co., 1238 Chestnut St., Newton Upper Falls, Mass.
General Electric Co., Schenectady, N. Y.
G-M Laboratories, Inc., 1731 Belmont Ave., Chicago, Ill.
Guardian Electric Mfg. Co., 1621 W. Walnut St., Chicago, Ill.
Hart Mfg. Co., 110 Bartholomew Ave., Hartford, Conn.
H-B Instrument Co., 2518 North Broad St., Philadelphia, Pa.
I-T-E Circuit Breaker Co., Philadelphia, Pa.
Kurman Electric Co., Inc., 241 Lafayette St., New York, N. Y.
Leland Electric Co., 1501 Webster St., Dayton, Ohio
McCorkle Co., D. H., 6th & Bancroft Way, Berkeley, Cal.
Mercoid Corp., 4201 Belmont Ave., Chicago, Ill.
Minneapolis-Honeywell Regulator Co., 2748 Fourth Ave. South, Minneapolis, Minn.
Monitor Controller Co., 51 S. Gay St., Baltimore, Md.
Penn Electric Switch Co., Des Moines, Iowa
Ranco, Sixth & Indianola Ave., Columbus, Ohio
Roller-Smith Co., 233 Broadway, New York, N. Y.
Rowan Controller Co., 2315 Homewood Ave., Baltimore, Md.
Russell Electric Co., 340 W. Huron St., Chicago, Ill.
Safety Car Heating & Lighting Co., New Haven, Conn.
Square D Co., 710 South Third St., Milwaukee, Wis.
Thompson, Inc., O., 18 Purvis St., Long Island City, N. Y.
Tork Clock Co., Inc., 31 South St., Mount Vernon, N. Y.
Trumbull Electric Mfg. Co., Plainville, Conn.
Ward Leonard Electric Co., 31 South St., Mount Vernon, N. Y.
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.
Weston Electrical Instrument Corp., 614 Frelinghuysen Ave., Newark, N. J.

SOLENOIDS

Allen-Bradley Co., 1326 S. 2nd St., Milwaukee, Wis.
Almo Mfg. Co., 471-475 Washington St., Newark, N. J.
Anderson & Co., C. J., 212-222 W. Austin Ave., Chicago, Ill.
Automatic Electric Co., 1033 W. Van Huron St., Chicago, Ill.
Automatic Switch Co., 154 Grand St., New York, N. Y.
Bock Oil Burner Corp., 124 S. Dickinson St., Madison, Wis.
Cutler-Hammer, Inc., 569 N. Twelfth St., Milwaukee, Wis.
Electric Controller & Mfg. Co., 2700 East 79th St., Cleveland, Ohio
Electric Valve Mfg. Co., 64 Murray St., New York, N. Y.
Friez & Sons, Inc.; Julien P., Baltimore St. & Central Ave., Baltimore, Md.
General Controls Co., 1370 Harrison St., San Francisco, Cal.
General Electric Co., Schenectady, N. Y.
Guardian Electric Mfg. Co., 1621 W. Walnut St., Chicago, Ill.
Hart Manufacturing Co., 110 Bartholomew Ave., Hartford, Conn.
Magnetic Mfg. Co., Milwaukee, Wis.
Mercoid Corporation, 4201 Belmont Ave., Chicago, Ill.
Minneapolis-Honeywell Regulator Co., 2748 Fourth Ave. South, Minneapolis, Minn.
National Acme Co., Cleveland, Ohio
Newark Boiler Regulator Co., 418 Glenwood Ave., East Orange, N. J.
Refrigerating Specialties Co., 714 S. Sacramento Blvd., Chicago, Ill.
Ross Operating Valve Co., Detroit, Mich.
Supreme Electric Products Corp., 79 Mt. Hope Ave., Rochester, N. Y.
Thompson, Inc., O., 18 Purvis St., Long Island City, N. Y.

Hydraulic Drives, Controls, Accessories

Bold face type indicates companies advertising in this issue

CYLINDERS, HYDRAULIC

American Broach & Machine Co., 415 W. Huron St., Ann Arbor, Mich.
Baldwin-Southwark Corp., Paschall P. O., Philadelphia, Pa.
Barnes Co., W. F. & John, Rockford, Ill.
Burroughs Engineering Co., 31 Clinton St., Newark, N. J.
Fairbanks, Morse & Co., 900 S. Wabash Ave., Chicago, Ill.
Hannifin Mfg. Co., 623 S. Kolmar Ave., Chicago, Ill.
Hydraulic Press Mfg. Co., Mount Gilead, Ohio
Logansport Machine Inc., Logansport, Ind.
Metalwood Mfg. Co., 3362 Wight St., Detroit, Mich.
Oilgear Co., Milwaukee, Wis.
Watson-Stillman Co., Aldene Road, Roselle, N. J.

FILTERS

Attwood Brass Works, Inc., 742 Front Ave., N. W., Grand Rapids, Mich.
Baldwin-Southwark Corp., Paschall P. O., Philadelphia, Pa.
Bowser & Co., Inc., 1300 E. Creighton Ave., Fort Wayne, Ind.
Cuno Engineering Corp., 80 So. Vine St., Meriden, Conn.
Elmes Engineering Co., Chas. F., Cor. Morgan and Lake Sts., Chicago, Ill.
Fisher Governor Co., Marshalltown, Ia.
Klemm Automotive Products Co., 2533 N. Ashland Ave., Chicago, Ill.
Logansport Machine Inc., Logansport, Ind.
Motor Improvements, Inc., 365 Frelinghuysen Ave., Newark, N. J.
Strong, Carlisle & Hammond Co., 1395 West 3rd St., Cleveland, Ohio
Zenith Carburetor Co., 696 Hart Ave., Detroit, Mich.

GAGES, PRESSURE INDICATING

Baldwin-Southwark Corp., Paschall P. O., Philadelphia, Pa.
Bristol Co., Waterbury, Conn.
Cleveland Steam Gage Co., Cleveland, Ohio
Consolidated Ashcroft Hancock Co., Inc., Bridgeport, Conn.
Crosby Steam Gage & Valve Co., 10 Roland St., Charlestown, Mass.
Elmes Engineering Co., Chas. F., Cor. Morgan & Lake Sts., Chicago, Ill.
Foxboro Co., 106 Neponset Ave., Foxboro, Mass.
Lonergan Co., J. E., 205 Race St., Philadelphia, Pa.
Marsh Corp., James P., 2073 Southport Ave., Chicago, Ill.
Pittsburgh Gage & Supply Co., Pittsburgh, Pa.
Schrader's Son, Inc., A. 470 Vanderbilt Ave., Brooklyn, N. Y.
United States Gauge Co., 44 Beaver St., New York, N. Y.

HOSE, Woven, Rubber.

Atlantic Metal Hose Co., Inc., 123 W. 64th St., New York, N. Y.
Cincinnati Rubber Mfg. Co., Franklin Ave. & B. & O. R. R., (Norwood) Cincinnati, Ohio
Consolidated Packing & Supply Co., 19 Barclay St., New York, N. Y.
Eastman Mfg. Co., 1002 N. 11th St., Manitowoc, Wis.
Eclipse Aviation Corp., 545 N. Arlington Ave., East Orange, N. J.
Flex-O-Tube Co., 750 14th St., Detroit, Mich.
Goodrich Co., B. F., Akron, Ohio
Goodyear Tire & Rubber Co., Akron, Ohio
Hewitt Rubber Corp., 240 Kensington Ave., Buffalo, N. Y.
Manhattan Rubber Mfg. Co., 61 Willett St., Passaic, N. J.
New York Belting & Packing Co., 1 Market St., Passaic, N. J.
Quaker City Rubber Co., 1935 Wharton Ave., Philadelphia, Pa.
Thermoid Rubber Co., Whitehead Rd., Trenton, N. J.
Titeflex Metal Hose Co., 500 Frelinghuysen Ave., Newark, N. J.
U. S. Rubber Products Inc., 1790 Broadway, New York, N. Y.
Weatherhead Co., 1387 W. Ninth St., Cleveland, Ohio

MOTORS, HYDRAULIC

American Broach & Machine Co., 415 W. Huron St., Ann Arbor, Mich.
American Engineering Co., 2501 Armingo Ave., Philadelphia, Pa.
DeLaval Steam Turbine Co., Trenton, N. J.
Hydraulic Press Mfg. Co., Mount Gilead, Ohio
Logansport Machine Co., Logansport, Ind.
Northern Pump Co., 920 18th Ave., N. E., Minneapolis, Minn.
Oilgear Co., 1351 W. Bruce St., Milwaukee, Wis.
Vickers Inc., 1400 Oakman Blvd., Detroit, Mich.

PACKINGS

Auburn Leather Goods Co., Hartford, Conn.
Baldwin-Southwark Corp., Paschall P. O., Philadelphia, Pa.
Belmont Packing & Rubber Co., Butler & Sepviva Sts., Philadelphia, Pa.
Chesterton Co., A. W. 64 India St., Boston, Mass.
Chicago Belting Co., 113-125 N. Green St., Chicago, Ill.
Chicago Rawhide Mfg. Co., 1301 Elston Ave., Chicago, Ill.
Cincinnati Rubber Mfg. Co., Franklin Ave. & B. & O. R. R., (Norwood) Cincinnati, Ohio
Consolidated Packing and Supply Co., 19 Barclay St., New York, N. Y.
Continental Rubber Co., 1932 Liberty Blvd., Erie, Pa.
Crandall Packing Co., Palmyra, N. Y.
Crane Packing Co., 1800 Cuyler Ave., Chicago, Ill.
Elmes Engineering Co., Chas. F., Cor. Morgan & Lake Sts., Chicago, Ill.
Excelsior Leather Washer Mfg. Co., 720-730 Chestnut St., Rockford, Ill.
Federal Metallic Packing Co., 43 Foundry St., Wakefield, Mass.
Felt Products Mfg. Co., 1504 Carroll Avenue, Chicago, Ill.
Garlock Packing Co., Palmyra, N. Y.
Goetz Gasket & Packing Co., Inc., S. New Brunswick, N. J.
Goodrich Co., B. F., Akron, Ohio
Goodsell Packing Co., 1803 Belle Plaine Ave., Chicago, Ill.
Graton & Knight Co., 356 Franklin St., Worcester, Mass.
Greene Tweed & Co., 109 Duane St., New York, N. Y.
Hewitt Rubber Corp., 240 Kensington Ave., Buffalo, N. Y.
Houghton & Co., E. F., 240 W. Somerset St., Philadephia, Pa.
Hydraulic Press Mfg. Co., Mount Gilead, Ohio
Jenkins Bros., 80 White St., New York, N. Y.
Johns-Manville, 22 E. 40th St., New York, N. Y.
Manhattan Rubber Mfg. Co., 61 Willett St., Passaic, N. J.
Marsh Co., C. W., Muskegon, Mich.
Metalwood Mfg. Co., 3362 Wight St., Detroit, Mich.
Michigan Leather Packing Co., 750-14th Ave., Detroit, Mich.
New Jersey Asbestos Co., 2 Water St., New York, N. Y.
New York Belting & Packing Co., 1 Market St., Passaic, N. J.
Packing Engineering Corp., Cranford, N. J.
Quaker City Rubber Co., 1935 Wharton Ave., Philadelphia, Pa.
Schieren Co., Chas. A., 29 Ferry St., New York, N. Y.
Simplex Mfg. Co., 15 Franklin St., Auburn, N. Y.
Thermoid Rubber Co., Whitehead Rd., Trenton, N. J.
U. S. Indestructible Gasket Co., Brooklyn, N. Y.
U. S. Rubber Products Inc., 1790 Broadway, New York, N. Y.
Walker Packing Co., Inc., James, 96-98 Liberty St., New York, N. Y.
Watson-Stillman Co., Aldene Rd., Roselle, N. J.

PIPE
• Steel

Allegheny Steel Co., Brackenridge, Pa.
Globe Steel Tubes Co., 3839 W. Burnham St., Milwaukee, Wis.
Hydraulic Press Mfg. Co., Mount Gilead, Ohio
Jones & Laughlin Steel Corp., Jones & Laughlin Bldg., Pittsburgh, Pa.
Pittsburgh Steel Co., Union Trust Bldg., Pittsburgh, Pa.
Republic Steel Corp., Republic Bldg., Cleveland, Ohio
Sharon Tube Co., 249 N. Water Avenue, Sharon, Pa.
Youngstown Sheet & Tube Co., Youngstown, Ohio

PIPE
• Non-ferrous

American Brass Co., 414 Meadow St., Waterbury, Conn.
Baltimore Tube Co., Inc., Baltimore, Md.
Bridgeport Brass Co., E. Main St., Bridgeport, Conn.
Chase Brass & Copper Co., 236 Grand St., Waterbury, Conn.
Foster Wheeler Corp., 165 Broadway New York, N. Y.
General Devices & Fittings Co., 1450 Buchanan Ave., S. W., Grand Rapids, Mich.
Mueller Brass Co., 1925 Lapeer Ave., Port Huron, Mich.
National Copper & Smelting Co., 1862 East 123rd St., Cleveland, Ohio
Revere Copper & Brass Inc., 230 Park Ave., New York, N. Y.
Scovill Mfg. Co., 35 Mill St., Waterbury, Conn.

PIPE FITTINGS
• Steel

Allegheny Steel Co., Brackenridge, Pa.
Attwood Brass Works, Inc., 742 Front Ave., N. W., Grand Rapids, Mich.
Chapman Valve Mfg. Co., Indian Orchard, Mass.
Crane Co., 836 S. Michigan Ave., Chicago, Ill.
Elmes Engineering Co., Chas. F., Cor. Morgan & Lake Sts., Chicago, Ill.
Hydraulic Press Mfg. Co., Mount Gilead, Ohio
Kennedy Valve Mfg. Co., Elmira, N. Y.
Limbert & Co., Geo. B., 570 Fulton St., Chicago, Ill.
Lunkenheimer Co., Cincinnati, Ohio
Reading-Pratt & Cady Co., Inc., 929 Connecticut Ave., Bridgeport, Conn.
Tube-Turns, Inc., 425 S. Fifth St., Louisville, Ky.
Vogt Machine Co., Henry, Louisville, Ky.
Walworth Co., 60 E. 42nd St., New York, N. Y.
Watson-Stillman Co., Aldene Road, Roselle, N. J.

PIPE FITTINGS
• Non-ferrous

Brass Products Co., 3661 Palmer Ave., East, Detroit, Mich.
Bridgeport Brass Co., E. Main St., Bridgeport, Conn.
Chase Brass & Copper Co., 236 Grand St., Waterbury, Conn.
Commonwealth Brass Corp., 5835 Commonwealth Ave., Detroit, Mich.
Crane Co., 836 S. Michigan Ave., Chicago, Ill.
Lunkenheimer Co., Cincinnati, Ohio
Mueller Brass Co., 1925 Lapeer Ave., Port Huron, Mich.
National Copper & Smelting Co., 1862 East 123rd St., Cleveland, Ohio
Nugent & Co., Inc., Wm. W., 414 N. Hermitage Ave., Chicago, Ill.
Parker Appliance Co., Cleveland, Ohio
Sterling Cable Corp., Port Huron, Mich.
Tube-Turns, Inc., 425 S. Fifth St., Louisville, Ky.
Weatherhead Co., 1387 W. Ninth St., Cleve'and, Ohio

PUMPS
• Reciprocating

Aldrich Pump Co., 1 Pine St., Allentown, Pa.
Baldwin-Southwark Corp., Paschall P. O., Philadelphia, Pa.
Chambersburg Engineering Co., Chambersburg, Pa.
Dunning & Boschert Press Co., Inc., Syracuse, N. Y.
Fairbanks, Morse & Co., 900 S. Wabash Ave., Chicago, Ill.
Goulds Pumps Inc., Fall St., Seneca Falls, N. Y.
Homestead Valve Mfg. Co., 10 Box H, Coraopolis, Pa.
Hydraulic Press Mfg. Co., Mount Gilead, Ohio

Ingersoll-Rand Co., 11 Broadway, New York, N. Y.
Worthington Pump & Machinery Corp., Harrison, N. J.

PUMPS
• Rotary Gear

American Broach & Machine Co., 415 W. Huron St., Ann Arbor, Mich.
Barnes Co., W. F., & John, Rockford, Ill.
Bowser & Co., Inc., S. F., 1300 E. Creighton Ave., Fort Wayne, Ind.
Brown & Sharpe Mfg. Co., Providence, R. I.
DeLaval Steam Turbine Co., Trenton, N. J.
Fairbanks, Morse & Co., 900 S. Wabash Ave., Chicago, Ill.
Goulds Pumps Inc., Fall St., Seneca Falls, N. Y.
Hydraulic Press Mfg. Co., Mount Gilead, Ohio
Ingersoll-Rand Co., 11 Broadway, New York, N. Y.
Northern Pump Co., 920 18th Ave., N.E., Minneapolis, Minn.
Pittsburgh Steel Co., Union Trust Bldg., Pittsburgh, Pa.
Roper Corp., Geo. D., Blackhawk Ave., Rockford, Ill.
Tuthill Pump Co., 132 West 63rd St., Chicago, Ill.
Vickers Inc., 1400 Oakman Blvd., Detroit, Mich.
Viking Pump Co., Cedar Falls, Ia.
Worthington Pump & Machinery Corp., Harrison, N. J.

PUMPS
• Rotary Plunger

American Broach & Machine Co., 415 W. Huron St., Ann Arbor, Mich.
American Engineering Co., 2501 Armingo Ave., Philadelphia, Pa.
Hydraulic Press Mfg. Co., Mount Gilead, Ohio
Logansport Machine Co., Logansport, Ind.
Northern Pump Co., 920 18th Ave., N. E., Minneapolis, Minn.
Oilgear Co., 1351 W. Bruce St., Milwaukee, Wis.
Pittsburgh Steel Co., Union Trust Bldg., Pittsburgh, Pa.
Vickers Inc., 1400 Oakman Blvd., Detroit, Mich.

PUMPS
• Variable Displacement

American Broach & Machine Co., 415 W. Huron St., Ann Arbor, Mich.
American Engineering Co., 2501 Armingo Ave., Philadelphia, Pa.
Barnes Co., W. F. & John, Rockford, Ill.
Fairbanks, Morse & Co., 900 S. Wabash Ave., Chicago, Ill.
Hydraulic Press Mfg. Co., Mount Gilead, Ohio
Lapointe Machine Tool Co., 34 Tower St., Hudson, Mass.
Northern Pump Co., 920 18th Ave., N. E., Minneapolis, Minn.
Oilgear Co., 1351 W. Bruce St., Milwaukee, Wis.
Racine Tool & Machine Co., Racine, Wis.
Vickers Inc., 1400 Oakman Blvd., Detroit, Mich.

TUBING
• Flexible Metallic

Allegheny Steel Co., Brackenridge, Pa.
American Brass Co., 414 Meadow St., Waterbury, Conn.
American Metal Hose Branch, 67 Jewelry St., Waterbury, Conn.
Breeze Corporations, Inc., 24 So. Sixth St., Newark, N. J.
Bundy Tubing Co., 10951 Hern Ave., Detroit, Mich.
Chicago Tubing & Braiding Co., 1315 S. Third Ave., Maywood, Ill.
Eastman Mfg. Co., 1002 N. 11th St., Manitowoc, Wis.
Eclipse Aviation Corp., 545 N. Arlington Ave., East Orange, N. J.
Mueller Brass Co., 1925 Lapeer Ave., Port Huron, Mich.
National Copper & Smelting Co., 1862 East 123rd St., Cleveland, Ohio
Pennsylvania Flexible Metallic Tubing Co., 72nd St. & Powers Lane, Philadelphia, Pa.
Seamlex Corp., 5-15 48th Ave., Long Island City, N. Y.
Titeflex Metal Hose Co., 500 Frelinghuysen Ave., Newark, N. J.
United Metal Hose Co., Inc., 724-732 Garrison Ave., New York, N. Y.
Weatherhead Co., 1387 W. Ninth St., Cleveland, Ohio

TUBING
• Non-ferrous

American Brass Co., 414 Meadow St., Waterbury, Conn.
Baltimore Tube Co. Inc., Baltimore, Md.
Bridgeport Brass Co., E. Main St., Bridgeport, Conn.
Chase Brass & Copper Co., 236 Grand St., Waterbury, Conn.
Foster Wheeler Corp., 165 Broadway, New York, N. Y.
Mueller Brass Co., 1925 Lapeer Ave., Port Huron, Mich.
National Copper & Smelting Co., 1862 East 123rd Street, Cleveland, Ohio
Penn Brass & Copper Co., 1120-30 W. 18th St., Erie, Pa.
Revere Copper & Brass Inc., 230 Park Ave., New York, N. Y.
Roberts Tube Works, Detroit, Mich.
Scovill Mfg. Co., 35 Mill St., Waterbury, Conn.
Wolverine Tube Co., 1465 Central Ave., Detroit, Mich.

TUBING
• Steel

Allegheny Steel Co., Brackenridge, Pa.
American Tube Works, 440 Somerville Ave., Boston, Mass.
Bundy Tubing Co., 10951 Hern Ave., Detroit, Mich.
Detroit Seamless Steel Tube Co., Detroit, Mich.
Globe Steel Tube Co., 3839 W. Burnham St., Milwaukee, Wis.
Hydraulic Press Mfg. Co., Mount Gilead, Ohio
Ivins Steel Tube Works, Ellwood, Philadelphia, Pa.
Jones & Laughlin Steel Corp., Jones & Laughlin Bldg., Pittsburgh, Pa.
Michigan Seamless Tube Co., South Lyon, Mich.
Michigan Steel Tube Products Co., Detroit, Mich.
Ohio Seamless Tube Co., Shelby, Ohio
Pittsburgh Steel Co., Union Trust Bldg., Pittsburgh, Pa.
Reading Iron Co., Philadelphia, Pa.
Republic Steel Corp., Cleveland, O.
Roberts Co., C. A., 22 S. Aberdeen St., Chicago, Ill.
Steel & Tubes, Inc., 224 East 131st St., Cleveland, Ohio
Summerill Tubing Co., 30 W. Fourth St., Brideport, Montgomery Co., Pa.
Toledo Steel Tube Co., Toledo, Ohio
Youngstown Sheet & Tube Co., Youngstown, Ohio

VALVES

American Broach & Machine Co., 415 W. Huron St., Ann Arbor, Mich.
American Engineering Co., 2501 Armingo Ave., Philadelphia, Pa.
Attwood Brass Works, Inc., 742 Front Ave., N.W., Grand Rapids, Mich.
Baldwin-Southwark Corp., Paschall P. O., Philadelphia, Pa.
Barnes Co., W. F. & John, Rockford, Ill.
Bristol Co., Waterbury, Conn.
Burroughs Engineering Co., 31 Clinton St., Newark, N. J.
Chapman Valve Mfg. Co., Indian Orchard, Mass.
Crane Co., 836 S. Michigan Ave., Chicago, Ill.
Crosby Steam Gage & Valve Co., 10 Roland St., Charlestown, Mass.
Darling Valve & Mfg. Co., Williamsport, Pa.
Detroit Lubricator Co., 5842 Trumbull Ave., Detroit, Mich.
Dole Valve Co., 1913 W. Carroll Ave., Chicago, Ill.
Dunning & Boschert Press Co., Inc., Syracuse, N. Y.
Elmes Engineering Co., Chas. F., Cor. Morgan & Lake Sts., Chicago, Ill.
Fisher Governor Co., Marshalltown, Ia.
Fulton Sylphon Co., Knoxville, Tenn.
General Controls Co., 1370 Harrison St., San Francisco, Cal.
Hannifin Mfg. Co., 623 S. Kolmar Ave., Chicago, Ill.
Homestead Valve Mfg. Co., 10 Box H, Coraopolis, Pa.
Hunt and Son, C. B., Box 256, Salem, Ohio
Hydraulic Press Mfg. Co., Mount Gilead, Ohio
Jenkins Bros., 80 White St., New York, N. Y.
Kennedy Valve Mfg. Co., Elmira, N.Y.
Kerotest Mfg. Co., 2525 Liberty Ave., Pittsburgh, Pa.
LaBour Inc., 1301 Sterling Ave., Elkhart, Ind.
Lake Erie Engineering Corp., Buffalo, N. Y.
Logansport Machine Inc., Logansport, Ind.
Lunkenheimer Co., Cincinnati, Ohio
Marsh Corp., James P., 2071 Southport Ave., Chicago, Ill.
Mercoid Corp., 4201 Belmont Ave., Chicago, Ill.
Northern Pump Co., 920 18th Ave., N. E., Minneapolis, Minn.
Oilgear Co., 1351 W. Bruce St., Milwaukee, Wis.
Reading-Pratt & Cady Co., Inc., 929 Connecticut Ave., Bridgeport, Conn.
Ross Operating Valve Co., Detroit, Mich.
Vickers Inc., 1400 Oakman Blvd., Detroit, Mich.
Watson-Stillman Co., Aldene Road, Roselle, N. J.
Wolverine Brass Works, 820-848 Monroe Ave., Grand Rapids, Mich.
Wood Co., R. D., Wood Bldg., Philadelphia, Pa.
Yarnall-Waring Co., 102 E. Mermaid Lane, Chestnut Hill, Philadelphia, Pa.

HOW MEASURE CORROSION RESISTANCE?

This least standardized property of metals and alloys yields to improved *technique* and *devices*... *Inco* can now predict within reasonable limits how *long* metal equipment will *last.*

"HIGHLY resistant to corrosion by ——." How often you have seen those words in statements made about some metal.

And how often you have wondered, "Just how resistant is 'highly resistant'? How does one measure the quality?"

Let's say you are installing a new piece of equipment. Perhaps a dryer lining, which will be in contact with sodium chloride. Perhaps evaporator tubes for reclaiming rayon coagulation bath. Or any of a hundred other pieces of equipment, which will be subject to the attack of one or more of many other corrosive agents. You want to reach the *right* decision on what metal to use, knowing that its length of life will depend chiefly on its corrosion resistance. How can you best get accurate information?

It's not as simple as if you wanted to compare the metals for a physical property like hardness or ductility. With these, the methods and units of measurement have been carefully standardized. All you'd need to do is look up the comparative figures.

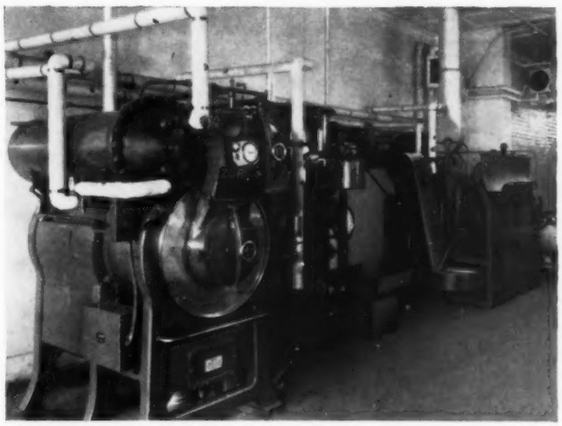
"Highly resistant" is a relative term. It usually implies comparison with some other materials. One metal may be *more*—much more—resistant to some specific agent than another. But seldom indeed is any metal *absolutely* resistant. How take the guesswork out of your choice?

One method is to write Inco Technical Service for advice. *They probably have made more extensive studies of corrosion, and have evolved more dependable methods of measuring it,* than any other group of men in America.

These facts are due to very definite reasons. It has been to our interest to spend time and money in studying corrosion. *One* of the chief advantages Nickel and its alloys have over most other metals is corrosion resistance. Further, Inco is interested in many different forms and alloys of Nickel, such as: Monel Metal, Ni-Resist, Inconel, Nickel Silver, K Monel and many ferrous nickel alloys.

And so we have made it our business to learn, not only how these metals compare with other metals, such as steel and bronze, but how they compare *with each other.* Obviously, some resist one corrosive agent better; others another. But one thing our studies have taught us is this: It is impossible to lay down broad general statements about corrosive effects. It is necessary to study with care the special conditions on each individual installation, as differences in temperature, degree of aeration and rate of motion often accelerate or retard the corrosion rate of the same agent on the same metal. The accompanying table, for instance, shows the results of tests made at the request of dry cleaning equipment manufacturers. Comparative field tests were made to determine the extent to which Monel Metal and Nickel resist corrosion at various locations in dry cleaning units.

Inco engineers either have or will secure the information you need on corrosion. Write them fully and specifically about the questions affecting your plant. Ask about their Corrosion Testing Service. The details of the interesting and accurate corrosion testing methods mentioned above are fully covered in our Technical Bulletin T-10, "*Corrosion Testing Methods.*" A copy is yours for the asking. Ask us also for a copy of List B, describing informative bulletins on Monel Metal and rolled Nickel.



Installation of 3018 ZORIC Dry Cleaning System at the plant of the Hinchey Laundry & Zoric Dry Cleaners, Omaha, Nebr. Monel Metal construction standard for shell and cylinder of washer, also combination still and storage tank. Manufactured by The American Laundry Machinery Company, Cincinnati, Ohio.

Results of Field Tests in Solvent Reclamation Equipment of Dry Cleaning Unit Handling Carbon Tetrachloride

Point of Test	Duration of Test	Corrosion Rates in Inches Penetration Per Year	
		Nickel	Monel Metal
Main Still Liquid	66 days	0.000035	0.00001
Main Still Vapor	66 days	0.00002	0.000025
Auxiliary Condenser Tubes	96 days	0.0015	0.0015
Auxiliary Condenser Shell (bottom)	128 days	0.00025	0.0005
Sump Tank	66 days	0.00007	0.0001
Main Storage Tank	98 days	0.00016	0.0002

THE INTERNATIONAL NICKEL COMPANY, INC., 67 WALL STREET, NEW YORK, N. Y.

WHEN your prospective customer checks all the outstanding features of your automobile, refrigerator, motor or adding machine, will he find rust-proofing?

Your prospect will make comparisons—and finish permanence may swing the decision.

With Parker Processes you can add an extra quality feature which gives your product the edge on competition. Parker Processes provide added protection to mechanical parts and greater stability to paint finishes. They give the salesman out on the firing line an extra talking point.

Parker Processes maintain the rust-free efficiency of working parts and assure the stability of lacquer or enamel.

For more than 21 years, this company has devoted its entire time, talent and energy to the improvement of rust-proofing methods. A new book, describing Parker Processes, is available to manufacturers and technical men. Write for your copy.

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